A HISTORY OF AIR FORCE CIVIL ENGINEERING WARTIME AND CONTINGENCY PROBLEMS FROM 1941 TO THE PRESENT

THESIS

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THESIS

Presented to the Faculty of the School of Systems and
Logistics of the Air Force Institute of Technology
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Master of Science in Engineering Management

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Abstract

Air Force Civil Engineering's (AFCE) lack of a consolidated historical document complicates and even precludes the use of past experiences by AFCE to plan for the future. Historical research techniques were used to consolidate AFCE historical information from the Simpson Historical Research Center, the Office of the Air Force Historian, the AFIT libraries, the AFLC archives, other university libraries, and interviews with several past Directors of AFCE and AFCE contingency experts. The findings from these, numerous sources are presented in six chapters: 1) experiences of aviation engineers during WWII; 2) experiences prior to and during the Korean conflict; 3) experiences of the post-Korea/ pre-Vietnam era; 4) problems and significant advancements of the Vietnam era; 5) AFCE evolution from the end of the Vietnam conflict to the present; and 6) a summary of significant findings and recommendations. This research indicates that AFCE problems of the past occurred and continue to occur because of technical deficiencies, economical limitations, political restrictions, and because AFCE has failed to properly learn and use lessons of the past to prepare for the future.

I. Introduction

Overview

The purpose of this research was to identify, analyze, and record wartime and contingency problems experienced by Air Force Civil Engineering (AFCE) and the development of solutions to these problems. Problems experienced during World War II, the Korean conflict, and the Vietnam conflict are addressed as wartime problems in this paper. The problems experienced during such situations as the deployment of military forces to prevent the attempted overthrow of the Lebanese Government in 1958 are considered as contingency problems.

There were three reasons why this research was conducted. The first was to give AFCE managers a perspective of the complexities of providing Civil Engineering support in a wartime or contingency environment. The second was to provide an historical data base and a bibliography of AFCE historical information which would allow AFCE managers at all levels to participate in identifying and pursuing solutions to potentially recurring AFCE wartime and contingency problems. A third was to record the wartime and contingency knowledge and experiences of as many current and past AFCE leaders and recognized contingency experts as possible.

The next section of this chapter provides the background and justification for the research of past AFCE

wartime experiences. The introduction then continues wi discussion of the research objective and research quest Finally, the introduction concludes with a brief presen tion of the scope and limitations of the research.

Chapter two discusses the methodology used to det what were the major AFCE wartime and contingency probl and how these problems should be researched and reporte The methodology also describes how historical events sh be validated, and how past war and contingency problems should be presented.

Chapters three through seven represent the followi time periods:

Chapter 3: WW II (1941-1945)
Chapter 4: Korean War Era (1946-1953)
Chapter 5: Post Korea Era (1954-1961)
Chapter 6: Vietnam Era (1962-1975)
Chapter 7: Post-Vietnam Era (1975-1984)

Each chapter addresses the problems encountered during a particular time period and the development of solutions problems experienced during and prior to that time peri

The eighth and final chapter presents the signific findings of the research and recommendations for future historical research.

Background and Justification

AFCE managers have a complex and multi-dimensional Routine everyday peace-time duties require AFCE managers maintain more than 115 billion dollars worth of faciliti which are located on 2934 installations world wide (141)

In addition to their maintenance and repair responsibilities, AFCE managers are responsible for developing and monitoring all Air Force (AF) facility alteration and construction. Between 1980 and 1984 more than 24 billion dollars were spent to improve, construct, and maintain AF facilities (141). This tremendous workload, and the ever increasing emphasis on reducing Federal spending, demands that the AFCE manager concentrate on improving peacetime productivity of his own work force. This leaves little time, and few resources, for what should be AFCE managers' number one concern: the preparation for war. Compounding the problem of preparing for war is the continuing loss of AFCE veterans with wartime and/or contingency experience.

More than ten years have passed since our involvement in Vietnam: the most recent war action of the Air Force. It has been 32 years since the Korean conflict ended and 40 years since the conclusion of War World II. The Military Personnel Center (MPC) estimated that as of August 1985 approximately 75% of current AFCE officers had entered active duty since 1971 (72). The number of AFCE personnel with war experience is low and obviously decreases each year due to the attrition of veterans by death or retirement. This loss of "war-wise" AFCE personnel, and the ever-increasing emphasis on peacetime productivity, requires that more AFCE managers become aware of past AFCE wartime problems to insure that AFCE's preparation for future war is

as effective (gets the job done right) and efficient (gets the job done with minimum expenditure of resources) as possible. To choose the right planning strategies and to take the proper initiatives for the future, the authors propose; as do historians, philosophers, and military theorists/experts; a sound knowledge of past experiences is essential.

Historians and Philosophers. Many philosophers and historians state that the study of history is important so we may learn "the lessons of the past". Some historians, however, take the same view as the Greek philosopher, Heraclitus, who wrote: "You cannot step twice in the same river, for fresh waters are ever flowing upon you" (39:5).

One could say that even this statement (that nothing repeats itself because the circumstances of every event are different) is in itself a "lesson" of history (39:4). However, the majority of historians appear to support the idea that history does provide valuable lessons which help us prevent the recurrence of "crimes and disasters" of the past (47:90). E. H. Carr, in his book What Is History wrote:

> The past is intelligible to us only in the light of the present; and we can fully understand the present only in the light of the past (157:102).

Sir Walter Raleigh, a historian and famous explorer, once wrote that the purpose of history "is to teach by the examples of times past such that wisdom may guide our

desires and actions" (47:91). Some historians warn that although there are events which recur, the events require careful analysis because of the changing circumstances which surround each event (151:2). Nevertheless, historians and philosophers state that "man's past, present, and future interlock at every moment" (197:32), and that man can "rationally anticipate the future" only by studying "the process and events of the past" (39:35). Anticipating the future is one of the many decisions which military strategists must make.

Effective decision making is an essential element in the planning and preparation for war. Many historians and philosophers state that the study of history is vital to effective decision making because it provides the empirical data used to make decisions and because the study of history increases the intellectual capacity of its students (39:6). According to Strayer, in his book _The Interpretation of History_:

> Even in our daily lives we cannot make decisions without drawing on our stock of generalizations which we have built up from the facts of our own personal history (28:13).

History, therefore, provides the data and reference points for effective decision making and it exercises and strengthens the mental capabilities of the decision maker.

The study of history helps a person to develop his or her ability to diagnose problems, a key to effective

decision making (260:50). Along with improving diagnostic skills, some historians believe the study "fires the imagination" of the student of history (47:92). Improving the intellectual prowess and the decision making skills of the AFCE manager should help prevent the recurrence of mistakes and problems of past wars.

The primary reason for studying history is to learn from previous experiences so that progressive improvements can be made. For the AFCE manager, this desired progress would be in the form of improved facility support and wartime fighting capability. Progress, according to George Santayanna, a famous and much quoted philosopher, depends on a sound knowledge of history:

> Progress, far from consisting in change, depends on retentiveness. When change is absolute there remains no being to improve and no direction is set for possible improvement; and when experience is not retained, as among savages, infancy is perpetual (260:82).

Many historians agree with Santayana's emphasis on the importance of using history to prevent the recurrence of past mistakes. One historian illustrates the importance and the effectiveness of using historical analysis as a planning guide when he states that the United States Constitution was a by-product of "scrupulous attention to the experiences of earlier republics" (108:106). Historians such as Wood Gray and the other authors of <u>Historians Handbook: A Key to the Study and Writing of History</u> magnified the usefulness of historical analysis in planning when they wrote:

> Man's unique ability to incorporate into his personal experience that of other men and women, not only of his own time but of all previous generations, is a true second sight that sets him above other species and enables him to better understand the present in order to prepare himself to face the problems of the future (99:6).

Some historians contend that not only is historical analysis important to the planning process, it is the basis for all thought (99:6). Many, like John Highman, argue that because history is the basis for all thought, historical analysis is vital to "all purposes of life" (1Ø7:ix). Historians, and many philosophers, therefore appear to stress four main ideas. These ideas are:

1. Studying the past can provide today's planners and strategists with historical lessons that can assist them to avoid or to better handle recurring problems.

2. Historical analysis can provide data for and increase the intellectual capabilities of decision makers.

3. The study of past events is a prerequisite of effective planning and, therefore, is an essential element of progress.

4. Historical analysis provides the basis of all thought and, therefore, applies to "all purposes of life".

Although the arguments of many historians and philosophers appear to be intuitively logical, one could argue that these arguments are biased because the livelihood of historians depends on how well they promote the importance of history. Some AFCE managers may also argue that their role is to strictly manage the operations of their job and

leave the study of history to those specifically assigned the responsibility of studying past war and contingency experiences. For these busy people, we draw their attention to the interesting note that many management theorists are also strong proponents of historical analysis; and it surely should be said these experts, and their livelihood, are not dependent on convincing others of the importance of history.

Management Theorists. The rapid advancement of technology has forced military leaders to become more management oriented. According to Morris Janowitz, in his book The Professional Soldier, "as the military establishment becomes progressively dependent on technology, the importance of the military manager increases" (144:22). The growing number of high-technology weapon systems is generating more demands on the AFCE manager. For example, the F-16 multi-role fighter with its increased wheel loading has resulted in a demand for increased pavement strength at existing air bases and bare bases constructed to support war and contingency operations. Maintenance facilities for the avionics of the F-16, the F-15, and the new TR-1 require power which is non-fluctuating and which is supplied simultaneously at many different voltages, amperages, and frequencies. The organization and training of AFCE personnel to deploy anywhere in the world, with minimum notification, to support the projection of United States air power, is in itself, a demanding managerial task. AFCE managers should, therefore, know what

management theorists have to say about the importance of historical analysis in becoming an effective manager.

A majority of management theory literature indicates that to be better managers, it is important to know about the historical development of management. Many authors of management textbooks begin their books and introduce different management ideas by first discussing the history of management or the history behind a certain management philosophy. For example, Richard M. Hodgetts introduces his book Management: Theory Process and Practice, by asking the question:

> How can one truly understand where the field of management is, or where it is going without some knowledge of where it has been (139:2).

Basically, many management theorists agree that to become a better manager one must combine new management techniques with "traditional wisdom " (229:vi) It is interesting to note that many management theorists state that studying management history is vital to becoming a better manager, but do not mention whether or not managers should study the history of their organizations. Some management theorists have expressed the opinion that historical analysis is of little benefit to an organization and managers should, therefore, be concerned only with the future (239:41). Henry Ford, the famous automotive industrialist, expressed such sentiments when he reportedly stated "all history is bunk" (239:41). Ross A. Webber, however, is quick to point

out that this disregard for historical analysis can be disastrous (239:41). According to Webber, "Henry Ford's inadequate understanding of history contributed to the late 1920s decline in the Ford Motor Company's fortunes" (239:41). Ford, in his attempt to make production more efficient by total standardization, forgot one important historical factor. According to Webber, Ford forgot the "historical development of the public's desire for increased choice and luxury" (239:41). The result was a decline in sales equal to the sales decline of horse-drawn buggies when Ford offered the people more luxury and variation in transportation modes in the form of the Model-T (239:41). Other management theorists, like Webber, have recognized the importance of historical analysis.

Richard J. Tersine in his book Production/Operations Management: Concepts, Structure, and Analysis states that "the past is where the problem is identified and diagnosed" (225:43). James H. Donnelly and other authors of Fundamentals of Management suggest that in order to build sound strategic plans " . . . the critical characteristics and events of the past must be considered . . ." (69:131). Michael Sanderson, in his book Successful Problem Management, states that a review of the past can help managers to avoid the proverbial "re-invention of the wheel" (199:13). These management theorists and many others agree with the historians and philosophers that history is essential to the development of sound planning.

Military Leaders and Theorists. Many military authorities feel historical analysis is the key to success. Military strategists constantly study previous wars and conflicts to prepare for future wars. General Douglas MacArthur explains why historical analysis is important to the military man:

> More than most professions, the military is forced to depend on intelligent interpretation of the past for signposts charting the future. Devoid of opportunity, in peace, for self-instruction through actual practice in his profession, the soldier makes maximum use of the historical record to function efficiently in emergency. The facts derived from historical analysis, he applies to conditions of the present and proximate future, thus developing synthesis of appropriate method, organization, and doctrine (68:preface).

Admiral James Stockdale has written:

> The single most important foundation for any leader is a solid academic background in history . . . That discipline (history) gives perspective to the problems of the present and drives home the point that there is really very little new under the sun (223:66).

The study of military history and theory was formalized with the reorganization of the Prussian Ministry of Defense in 1806 (73:174). The reorganization of the Prussian military organization yielded a new office which was responsible for planning and organizing, and then accomplishing the peacetime training and education of the army (73:174). The study of military history became one of the primary

responsibilities of the Prussian General Staff (73:179). Karl von Clauswitz, an experienced soldier and author of the classic treatise On War, believed that:

> . . . the knowledge that is basic to theory, whether of war or of anything else, must be empirical . . . and that for the study of war, historical examples form the whole of one's empirical data (151:255-266).

Clauswitz also served as an instructor at the Prussian military academy which stressed the importance of studying military history. Count Helmuth von Moltke, a student of Clauswitz, was another proponent of studying military history.

Count von Moltke became the commanding general of the Prussian Army in late 1800s. Moltke once wrote that the study of history was essential for:

> acquainting a future commander with the complexity of circumstances under which military action could take place . . . that no staff or army maneuvers, indispensable as they were for training of staff officers, could put before their eyes a realistic picture of the significant aspects of war as history was able to do (73:179).

The superiority of the Prussian Army during the 1860s was primarily due to its organization, peacetime training, and the theoretical study of war (73:172). While these justifications for the need to study history appear to apply primarily to the fighting man, a direct application to military engineers is easily established.

History indicates that military engineers have been and will probably remain an important element of warfare. The

fall of the Babylonian Empire and the subsequent rise of the Assyrian Empire "marked the birth of military engineering" (86:16). This "birth" of military engineering began under the Assyrian emperor, Tiglathpileser I, about 1100 B.C. (86:16). By 670 A.D. Memphis, the ancient capital of Egypt, fell to the Assyrians who had developed such things as a light armored wagon (the forerunner of the tank), pontoon bridges made of animal skins, and fortifications made of walls, towers, and moats (86:16). The invention of gunpowder and the cannon in the 1500s ended the castle building introduced by the Assyrians (86:86). The Italian Renaissance engineers developed a new type of fortification which could withstand a siege of cannon fire much better than stone castle walls. The polygon star-shaped earthwork fortification with bastions was introduced by Francesco di Giorgio Martinie (1439-1502) (86:118-119). According to James K. Finch in his book <u>The Story of Engineering</u>, "the Renaissance witnessed the development of military engineering as a distinct profession" (86:119). The recognition of the importance of the military engineer continues today.

Lieutenant General Phillip C. Gast re-emphasized the importance of military engineers in a 1981 article (Operations & Engineering: Readiness Partners) in the "Air Force Engineering & Services Quarterly" when he stated ". . . many battles have been won or lost due to an

engineering feat" (89:10). Addressing the peacetime and wartime missions of AFCE Brigadier General George E. (Jud) Ellis acting as the Deputy Chief of Staff of Engineering and Services, Tactical Air Command, in 1983 re-confirmed the importance of knowing our history when he stated:

> The Air Force Civil Engineering and Services family needs a special perspective to meet our future challenges. We need a perspective that is a healthy marriage of experience and vision . . . (218:16).

The importance of studying AFCE history is also recognized by Major General Clifton D. Wright, the Director of Engineering and Services. General Wright stated in a 12 April 1985 interview with the authors of this paper that all AFCE managers should study and know the history of AFCE. He explained that AFCE managers often get too caught up in their day-to-day jobs to reflect on experiences of their predecessors and the past. According to General Wright, this, unfortunate disregard for history is the by-product of demanding jobs, which require AFCE managers to put in more than just an eight-to-five day, and the lack of a consolidated and easily accessible history of AFCE. General Wright, while addressing the annual Air Force Institute of Technology Program Review Committee, 11 April 1985, and again during the 12 April 85 interview, stated that the AFCE community has done a poor job of recording its history and that other Air Force historical documents

rarely, if ever, addressed the experiences of AFCE. General Wright said that he was committed to insuring that AFCE's history is recorded and that to accomplish this objective he was currently trying to establish a permanent headquarters manpower position for an AFCE historian. General Wright emphasized several times during the interview that a complete and consolidated history of both peacetime and wartime experiences was needed to provide AFCE managers with the perspective that peacetime duties and wartime duties are really inseparable; that during times of peace we cannot forget that our primary responsibility is to prepare to support Air Force contingency and wartime operations, and during war AFCE managers cannot forget the training, accomplishments, failures, and events which were experienced during times of peace. General Wright explained that maintaining a clear perspective of peacetime and wartime experiences is essential if AFCE managers are to effectively transition between peacetime, wartime, and contingency operations. Although the need for a history of AFCE is clearly evident, there is no consolidated history of AFCE experiences which can provide AFCE managers with this perspective.

Specific Research Problem

There are many sources of AFCE war strategies, initiatives, experiences, and warfighting capabilities. These sources take the form of unit histories, major command histories, research papers, books, "Air Force Engineering &

Services Quarterly" and other pertinent periodicals, letters and diaries of commanding officers, and end-of-tour reports by AFCE commanders. However, even with this vast number of individual histories, there is no single document which ties or integrates these different histories together. The absence of a comprehensive history of AFCE war fighting experiences makes it more difficult and time consuming for the AFCE manager to attempt to study and analyze past AFCE war experiences. The absence of a comprehensive historical record will require more intensive research by the already extremely busy AFCE manager who will likely be either discouraged from attempting to study past war experiences or he or she will be severely hampered by the vast number of documents which must be read to gain a sound understanding of these experiences. The lack of a single repository of AFCE historical records also poses a major problem for the AFCE manager. The historians and strategists who have been assigned the responsibility of studying past war experiences can easily overcome the problems stemming from the vast number of historical records which must be, first, gathered from many locations and then read, because they have the time and resources to do these things. But, should the typical AFCE manager or commander be excluded from the opportunity to study the past war experiences because he or she does not have these same resources. Leonard M. Marsak, author of <u>The Nature of Historical Inquiry</u>, explained why everyone should be involved in the study of history:

> No one can profit by historical research, or not much, unless he does some for himself. Historical knowledge, however richly stored in books or in the minds of professors of history, is no good to (us) unless (I) have some of it (157:44).

A single comprehensive history of past AFCE war experiences would allow more AFCE managers to do some of their own study and more could, therefore, participate in the development of solutions to problems which have not been resolved. AFCE managers could also use the comprehensive history to better prepare themselves and their personnel for future conflicts. There are, therefore, two basic research problems. The first is to determine what experiences should be classified as important historical events. The second is to collect, review, and consolidate these experiences into one comprehensive historical report for dissemination to AFCE managers. These two research problems can be more precisely analyzed in the form of research questions.

Research Questions

The primary research objective was to develop a historical record of past AFCE wartime and contingency experiences which would be specific enough to be used by AFCE managers as a decision foundation when contemplating future wartime strategies and initiatives. One secondary objective was to collect vital historical information which is in the form of unrecorded knowledge and experience possessed by past Directors of Air Force Civil Engineering,

other top AFCE leaders, and recognized contingency experts. Another secondary objective of this research is to provide future researchers with a secondary source of historical information and a comprehensive bibliography of primary historical information. To provide a comprehensive historical review, which can be used to improve the overall effectiveness of AFCE, this paper attempted to answer the following research questions.

1. What were the major wartime and contingency problems that were experienced by AFCE from 1947 to the present?

2. What were the solutions to these problems and how effective were these solutions in terms of mission accomplishment within resource constraints?

3. Have there been any recurring problems and, if so, why did they recur?

4. What has been done and what is being done to prevent or reduce the impact of these recurring problems?

The preceding objectives and questions address only the wartime perspective. The reasons for limiting the scope of the research are presented in the next section of this introduction.

Scope and Limitations

As previously mentioned, General Wright stated that a comprehensive history of both peacetime and wartime experiences is needed. The authors concur with General Wright. Unfortunately, the limited time available for the student

authors to accomplish this research necessitated the scope of this paper be reduced to the wartime and contingency problems that have been experienced by AFCE. The lack of time to accomplish a complete and comprehensive AFCE historical document is the result of two factors. The first factor is the lack of previously recorded AFCE histories. Except for a few after-action reports of contingency operations, brief references in Air Force historical documents, and a research report of AFCE wartime capabilities by Lt Col Floyd A. Ashdown, there are no available histories of AFCE. Obtaining data from primary sources such as unit histories, end-of-tour reports, and interviews requires extensive and time consuming research at many locations. The second factor was the limited experience levels of the authors with respect to AFCE contingency experiences and with respect to the techniques of researching and writing history. The lack of previous AFCE historical documents and the lack of expertise of the authors required that the scope of this particular research be limited to wartime and wartime problems experienced by AFCE.

Even this reduced scope of researching and recording the AFCE wartime and contingency problems was further limited by the available time and by other factors such as the security classifications of many valuable sources of historical information. This research report does not include classified material, so that it will be easily

accessible to all AFCE managers and future researchers. Eventually, many classified documents will be declassified and the information contained in them can be included in future AFCE historical documents of general use and availability.

Although this research has been limited to AFCE wartime and contingency problems, an attempt has been made to identify other areas of AFCE history which should also be researched and recorded. These topic areas which are detailed in Chapter VIII should be researched and recorded so that eventually a complete and comprehensive AFCE history can be established.

II. Methodology

Introduction

The initial objective of this research was to develop a detailed and comprehensive historical paper on AFCE wartime experiences, strategies, and initiatives. Because of the extremely large number of primary and secondary historical sources and the broad nature of the topic, it was necessary to limit or, as Block recommends, to "narrow down" the topic (33:99). A two phase approach was used to scale down the topic. First, the available primary and secondary sources on AFCE warfighting capabilities, strategies, and initiatives were reviewed from several locations. These included the Simpson Historical Research Center and the Air University Library at Maxwell Air Force Base; the Air Force Institute of Technology School of Engineering and School of System and Logistics libraries at Wright-Patterson Air Force Base; and specific topic searches were conducted through the Defense Technical Information Center (DTIC). From these reviews, several topical areas were identified. The second phase in narrowing down the topic consisted of interviewing, either by phone or in person, several top AFCE officers and Air Force historians using the previously identified topical areas as prompters during the interview or as an interview guide (77:214). Topical areas were selected based on their relative importance and the feasibility of accomplishing the

necessary research. The topic ultimately selected for this research was "A History of Air Force Civil Engineering Wartime and Contingency Problems, and the Development of Solutions to Those Problems from 1941 to the Present."

Although the narrowing down process was conducted throughout the research, these first phases sufficiently limited the topic to a manageable project so that a plan of action for obtaining, reviewing, and consolidating the source material could be formulated. This plan was developed based on the writings of several noted historians on the subject of teaching history and conducting historical research.

Phase I

Maxwell AFB. There were a large number of primary historical sources at the Simpson Historical Research Center and the Air University library. Primary sources are those items which could serve as evidence to be examined (46:10). These primary sources included many unit histories, the personal diaries of Air Force commanding officers, several Vietnam end of tour reports from AFCE commanders, as well as other letters, documents, and reports. In addition, copies of past and present USAF and United States Army (USA) regulations and agreements which pertained to airfield installation maintenance, repair, and construction, and the organization and responsibilities of the various USAF and the

parent USA units were obtained. From the study of these primary sources several topical areas were identified and are shown in a combined list on page 26.

Many secondary sources were also obtained. Secondary sources are those items which recall in context the required names and terms associated with the specific events identified from the primary sources (46:11). In addition to the many articles and papers reviewed, there were three significant secondary sources which stood out from the rest. The first of these was Far Eastern Air Forces (FEAFs) volumes I, II, and III published in 1954. These documents present a written and pictorial account of many of the events pertinent to the Air Force during the Korean conflict (82; 83). Another secondary source was Project CORONA HARVEST published by the Air Force in 1970. This document details an account and analysis of the AFCE successes and shortcomings during the Vietnam conflict (190). The third, and most relevant to this research, secondary source obtained was A History of Warfighting Capabilities of Air Force Civil Engineering, by Lt Col Floyd A. Ashdown. This Air War College research report presents a comprehensive study of AFCE warfighting capabilities from the time the Air Force became a separate service in 1947 through 1983. It includes a summarization of the early USAF and USA construction agreements, the accomplishments and shortcomings of these arrangements, the development of Prime BEEF and RED HORSE,

the roles and responsibilities of these units during contingencies, and their evolution after the Vietnam conflict (22). This research is similar to Ashdown's in that both present a record of AFCE's warfighting capabilities but differs from Ashdown's in two ways. First, this research focused on AFCE's wartime and contingency problem areas, especially recurring problems , and secondly, it related the strategies and solutions for the problems in their relative effectiveness as tested during wartime and contingencies.

From the aforementioned review, several other topical areas were identified and the following is the combined list of topical areas for further research:

1. The Special Category Army with the Air Force (SCARWAF) units which were used during the Korean conflict.

2. The responsibilities of Base Civil Engineers during wartime or in a contingency environment.

3. How AFCE organization and responsibilities have changed over the years.

4. USAF, USA, and United States Navy (USN) agreements.

5. AFCE problem areas identified during the Lebanon incident of 1958, the Berlin incident of 1961 as well as the Korean and Vietnam conflicts.

6. The evolution of Prime BEEF (Base Emergency Engineer Force).

7. The evolution of RED HORSE (Rapid Engineer Deployable Heavy Operations and Repair Squadron, Engineering).

8. A chronological listing of actual AFCE wartime experiences and strategies.

This list is not exhaustive of all of the possible topic areas that pertain to AFCE, but, is intended to include the issues relating to wartime and contingency situations of major concern to AFCE.

Wright-Patterson AFB. The AFIT libraries were limited in the amount of source material pertaining to AFCE. Although the extensive periodical and journal collection at the School Of Engineering Library contains numerous articles and writings that eventually proved useful in researching the topic selected, the amount of primary source material was extremely limited. Because of this, the list of topical areas already selected was not changed.

DTIC Search. DTIC is responsible for collecting, storing, reviewing, evaluating, synthesizing, repackaging, and disseminating authoritative scientific and technical information in formats useful to its users. A computer assisted search of the DTIC collection was conducted using the terms Civil Engineering and Military Engineering as first order terms, and then evolution, management, management engineering, management planning and control, military strategy, organizational structure, and strategy as they related to the first order terms. Although an extensive list of research papers was obtained, most of the abstracts of these papers did not indicate they would be useful to this research. The only usable paper listed, related to

this research, was Lt Col Ashdown's paper which was previously obtained from the Simpson Historical Research Center.

Phase II

<u>AFCE Interviews</u>. Using the previously identified list of topical areas as an interview guide, several top AFCE officers were interviewed. These included Brigadier General Ellis, Deputy Director of Air Force Engineering and Services at the Pentagon, Brigadier General Cornell, Deputy Chief of Staff for Engineering and Services for Air Force Logistics Command, and Lieutenant Colonel (Colonel selectee) Ashdown, Base Civil Engineer at Scott AFB. General Ellis was selected based on his high level AFCE position and his recognized expertise in AFCE wartime and contingency operations. General Cornell was also selected based on his high level AFCE position, and his extensive knowledge of AFCE history. In addition to be being AFCE contingency experts, Generals Ellis and Cornell were readily accessible. Lt Col Ashdown was selected because of his research on AFCE warfighting capabilities.

General Ellis was interviewed by phone in February of 1985. He was informed of the nature of the research and was asked about his impressions of the selected topical areas. He first indicated he would like to see an evaluation of the current Prime BEEF organizational structure. He was familiar with Lt Col Ashdown's paper and was very positive

on it; however, he stated that he would like to see more detail on the events pertaining to RED HORSE and Prime BEEF.

General Cornell was interviewed in person in February of 1985. He, too, was informed of the nature of the research and was asked about his impressions of the topical areas. He too was familiar with Lt Col Ashdown's paper, but also felt that since Prime BEEF and RED HORSE were such important aspects of AFCE's mission that these areas should be covered in as great detail as possible. In addition, he felt the wartime experiences of AFCE, as they pertain to day-to-day operations in a contingency environment, should be covered (52).

Lt Col Ashdown was contacted by phone in February of 1985. He felt that AFCE war experiences needed further research and elaboration and he, too, felt the current Prime BEEF organizational structure needed to be evaluated.

Historian Views. The Air Force Historian, Dr. Richard H. Kohn, during a visit to AFIT in the fall of 1984, was informed about the nature of the proposed research. He felt that the topic should be sufficiently limited to present a good historical account and to alleviate any limitations in time and resources. In addition he offered his offices' archives, in Washington, to aid in obtaining source material. He also cautioned that conclusions should be left up to the readers and not predetermined by the authors.

Dr. Herbert P. Carlin, from the office of the Air Force Logistics Command Historian, was also consulted

concerning the proposed research. He essentially concurred with Dr. Kohn, and he, too, offered the records of his office as a possible source of material.

Researching the Topic

As mentioned earlier, this research focused on AFCE wartime and contingency problem areas and the development of solutions to those problems. The topic was still very broad; however, the plan for researching it was developed based on the writings of several historical research authors. These experts differ on their recommended methods for accomplishing historical research. Some historians feel they have a responsibility to interpret their findings and anything less is not history (28:24-25; 30:79; 30:90). For example Strayer believes that:

> If formal history is to widen and deepen our personal experience, if it is to be a guide to action and not an escape from reality, it must make generalizations and draw conclusions (28:14).

Berlin also feels that we cannot judge the past because we already know the outcome (30:47) and he argues:

> The historian is, as we are told, not a judge but a detective; he provides the evidence, and the reader, who has none of the professional responsibilities of the expert, can form what moral conclusions he likes (30:166).

Several books and papers have been written on conducting historical research. These books were reviewed to aid in the development of the methodology for this research. Jeanette B. Coltham and John Fines detail, in a

1971 Historical Association Pamphlet, TH35, several characteristics that students and researchers of history should possess (46:16-20). The authors of this research were not professionally trained for historical analysis, extrapolation or drawing inferences, synthesis, making judgements, or evaluating historical evidence. For this reason, the authors of this research present the facts, avoid moral judgements, and let the reader draw the conclusions, for, as Berlin points out:

> . . . the historian no matter how detailed, clear headed, scrupulous, dispassionate, however skilled at imagining himself in other men's shoes is nevertheless faced with a network of facts so minute, connected by links so many and complex, that his knowledge; consequently his judgement, particularly his moral judgement, must always be founded in insufficient data; and if he succeeds in casting even a little light upon some small corner of the vast intricate pattern of the past, he has done as well as any human can ever hope to do (30:162).

Coltham and Fines coauthored their 1971 pamphlet titled "Educational Objectives for the Study of History", to attempt to present a framework which spells out the constituent parts that need attention in conducting and teaching historical research (46:3). This pamphlet resulted from the movement toward curriculum reform of the humanities, in the 1960s, and many of their ideas are controversial; however, the historical community has accepted many of Coltham and Fines' ideas as essential when conducting historical research (65:21). They present certain organizing procedures that were useful in conducting this research: Collect

and examine all the evidence, establish questions to be asked, recognize gaps in the evidence, and recommend appropriate steps to fill these gaps (46:12). Coltham and Fines also present a description of the category of product which resulted from this research. This thesis presents a "reproduction and description" of the major wartime experiences, the solutions and strategies that resulted from these experiences, and the conditions and factors which influenced these warfighting strategies and initiatives (Coltham:14).

Jack Block, in his book Understanding Historical Research, identifies methods by which students and researchers of history may engage in historical research (33:foreword). He states, as mentioned earlier, that the topic should first be sufficiently narrowed. Once this has been accomplished, he feels the researcher must formulate some general questions which he hopes to answer (33:99). These general questions take the form of what really happened, which side was responsible, where did it happen, why, who, etc.? Block believes these points are "absolutely essential" to the successful completion of a (historical) paper (33:99). This research was conducted using these guidelines.

Conducting the Research. The research plan involved three steps:

1. Developing the research questions which needed to be answered.

2. Collecting the appropriate source material to answer these questions.

3. Corroboration of the findings from the source material by interviewing several of the past Directors of Air Force Engineering and Services as well as other AFCE leaders.

Based on the writings of Block and Coltham several research questions were identified and were listed in the introductory chapter. The method of gathering information to answer these questions was similar to the method used in narrowing the topic. Since the nature of the research was essentially an extensive literature review which presents a consolidation of the large number of disjointed sources, the material from the previously mentioned libraries was combined with the material obtained from several additional libraries and archives. These included the National Archives in Washington D.C. and the files in the office of the Air Force Historian.

Following the extensive review of the literature, several of the past and present AFCE and Air Force Engineering & Services directors, and AFCE contingency operations experts were interviewed. Those interviewed are listed below:

Maj Gen Clifton Wright	Brig Gen George Ellis
Maj Gen William Gilbert	Brig Gen Joseph Ahearn
Maj Gen Billie McGarvey	Brig Gen Archie Mayes
Maj Gen M.R. Reilly	
Maj Gen Robert Curtin	

These interviews focused on events which occurred during each director's respective tour of office and their

experiences during their military careers. The main reason for conducting these interviews was to corroborate the findings from the literature review. Historians agree that first hand accounts increase the probability that the events actually occurred. For example, Joannis Craig includes in his rules of historical evidence the following propositions:

> Proposition I: Theorem I ~ Any history (not contradictory) confirmed by the testimony of one first witness has a certain degree of probability.[9:5]
>
> Proposition II: Theorem II ~ Historical probability increases in proportion to the number of primary witnesses who describe the event (131:5).

<u>Presentation</u>. This research presents the history of AFCE wartime and contingency problems in five chapters: 1) experiences of aviation engineers during WWII, where airpower first became a significant factor in warfare; 2) experiences prior to and during the Korean conflict, which was the first major test of the recently formed USAF; 3) experiences of the post-Korea/ pre-Vietnam era; 4) problems and significant advancements of the Vietnam era, where AFCE's greatest strides toward developing contingency capabilities were made; and 5) AFCE evolution from the end of the Vietnam conflict to the present. The last chapter of this thesis presents a summary of the major findings, presents some conclusions from this research, and lists some recommended areas for further study.

III. World War II (WWII) Era (1941-1945)

The most logical date to begin a history of Air Force Civil Engineering (AFCE) wartime and contingency problems would seem to be 26 July 1947. On this date, the 80th Congre s passed the National Security Act of 1947 (Public Law 253), which established the United States Air Force as a separate executive department under the also newly formed National Military Establishment (renamed as the Department of Defense in the 1949 Amendment of the National Security Act) (166:503). However, the first recognizable air force civil engineering units were established just prior to U.S. involvement in World War II (97:32). These aviation engineering units, although controlled by the Army, were established to support the Army Air Forces' flying operations. This history will, therefore, begin with the establishment of these aviation engineering units on 4 June 1940.

World War II was definitely a catalyst for the growth and recognition of the importance of United States air power. Events such as the German invasion of Poland in September 1939 and the defeat of the French Army in May 1940 prompted the President to direct a tremendous increase of aircraft and airmen (17). A goal of a 50,000 aircraft per year production rate was established increase the then meager force of less than 3,000 aircraft (17). A program was initiated to train 30,000 pilots and 70,000 mechanics

per year to support the proposed armada of aircraft (17). This rapid increase of U.S. airpower resulted in a "new and more autonomous setup for army operation" (17). An Assistant Secretary of War for air position was established and the War Department reorganized to place the Chief of the Army Air Forces under the direct control of the Chief of Staff (17). The following statement made by General "Hap" H. Arnold, the Chief of the Army Air Forces indicated the importance of aviation engineers had not been overlooked.

> Whereas a little over a year ago the term "aviation engineer" had no real official significance, we now recognize that it would be no wiser to send a long range bomber out minus a navigator than to attempt to operate an air force without the specially trained aviator components of the Corps of Engineers that has been assigned by the War Department to work intimately with us (17).

Colonel Stuart C. Godfrey, who was the Air Engineer, Army Air Forces Headquarters, on General Arnold's staff for the first years of WWII, re-emphasized the need for specially trained aviation engineers. He wrote that although the general engineers of the Army's Service of Supply (SOS) were able to meet the relative simple support requirements of the unsophisticated World War I aircraft, engineers specifically trained in runway and airfield construction would be needed to support the modern WWII aircraft which were much faster, heavier, and more complex (94).

General Arnold recognized the importance for engineering units which were specifically trained,

organized, and equipped to support Army Air Force operations, and he began negotiations with the Chief of Engineers before U.S. involvement in WWII for such a capability (97:239). The aviation engineer concept was based on small groups of men with special construction skills, which were to be trained and equipped to rapidly construct, repair, maintain, camouflage and defend, if necessary, air bases in forward areas (97:32; 39:239; 146; 193:TAB B-1). These engineering units were to be assigned to air forces in the various theaters of operations to support flying operations. General Arnold successfully negotiated this concept with the Army Chief of Engineers, and in August 1939 established a small detachment (one officer and three enlisted men) (39) which was assigned to General Headquarters, Air Force (GHQAF) (94). The first field aviation engineering unit was established on 4 June 1940 when the 21st Engineers (General Service) Regiment was redesignated as the 21st Engineer (Aviation) Regiment (97:32; 39:239). By February of 1945, the aviation engineers reached a peak strength of 117,851 personnel (39:239). Aviation engineers amounted to approximately 5% of the total Army Air Forces (7:1).

Initially, the engineer aviation units were not to have the capability or the responsibility to perform heavy construction (97:35; 39:239) also they were to have no peacetime role for repair, maintenance or construction (97:35). In November of 1940 at the request of the Army Air Forces, the responsibility for construction was transferred

from the Construction Quartermaster of the Army to the Civil Works of the Corps of Engineers (7:2). Meanwhile, the aviation engineers continued to push for some construction capability (97:35). A report on the construction of the Royal Air Force (British Air Force) airfields in France during the winter of 1940-1941 indicated that the British were too dependent on army engineers. This coupled with constant pressure from Lieutenant Colonel Donald A. Davison, the first Commander of the 21st Engineer (Aviation) Regiment, convinced the Chief of Engineers that the aviation engineers should have the capability to construct (even if heavy construction was required) airfields in forward locations (39:240). According to Army Air Forces Training Standard No. 40-8-1, the mission of the engineer aviation units were:

> Engineer aviation units assigned to the Army Air Force have the mission of assisting the Army Air Forces in the performance of assigned tasks in a theater of operation by the execution of engineering works. They are assigned to air forces and air task forces as required.
>
> Aviation engineers have the general mission of facilitating our Army Air Forces operations and opposing enemy operation. This is normally accomplished by engineer construction and at times by taking part in combat. The most important tasks are to construct and camouflage advanced airdromes, to maintain them under enemy attack, to assist in the defense, and to rehabilitate captured airdromes. All tasks are to be performed rapidly. Other missions are to provide the Army Air Forces with engineer supplies and to prepare and distribute special aeronautical charts and maps (237:1-2).

The aviation engineers were to be assigned to the air forces to support flying operations and were to train "intimately" (97:32) with the Air Forces so that they could

"speak and understand" (97:32) the special needs of Air Forces. The aviation engineers, however, worked more closely with the Corps of Engineers during the critical months prior to the war than they did with the air forces they were supposedly going to support in wartime (39:241). The prewar training of the 21st Engineer (Aviation) Regiment, however, was oriented toward supporting air force operations as they constructed the first pierced-steel-plank (PSP) runway during the Carolina Maneuvers in the fall of 1941. The 21st Engineer (Aviation) Regiment also experimented with portable hangars, various equipment items needed for airfield construction, and other expedient runway surfacing materials (97:37; 39:241). The first experience of aviation engineers supporting the Air Force in the field occurred during the Louisiana Maneuvers conducted during the month of September 1941 (94; 146:1). The 21st Engineering Regiment from Langley Field, Virginia, and Company C of the 810th Engineer Aviation Battalion from MacDill Field in Florida worked together to improve and camouflage airfields at Lake Charles Airport, Monroe Louisiana Airport, Beaumont Texas Municipal Airport, and Camp Beaureguard's Esler Field (146; 48).

Many aviation engineering units were not as fortunate as those units of the 21st Engineer (Aviation) Regiment and the 810th which received their initial indoctrination in an exercise maneuver or technical training center. Two such

units were the 803rd and the 804th, which were created from the 21st Engineer (Aviation) Regiment cadres and shipped immediately to the Hawaiian Islands in March and April of 1941 (173:1-2). These units were the first aviation engineers to see combat action during the Japanese attack on Pearl Harbor and Hickam Field on 7 December 1941 (173:1-2). The lack of training was not the only problem which the aviation engineers would encounter during WWII. Probably the biggest problem, at least in the eyes of the aviation engineers and the Air Forces, was the control and employment of aviation engineers by the Army or Navy. In fact, the absence of its own engineering forces and/or the lack of control of its own engineering forces would be a major problem for the Air Force from the beginning of WWII to the early years of the Vietnam War.

Control, Employment, and Organization of Aviation Engineers

Colonel J. O. Colonna, the Air Engineer for 12th Air Force and XII Air Forces Service Command from October 1942 to March 1943, once wrote:

> Any history of the Aviation Engineers is superficial unless we look behind the scenes at the policy making where we can see how these engineers were shaped into this engineer organization . . . (45:1).

The Army Air Forces were broken down into three distinct groups. First, the Headquarters Army Air Force was composed of the Chief of the Army Air Forces and his staff (17:1). Secondly, there was the Army Air Corps which was

the arsenal of the Air Forces containing the flying equipment and trained pilots and aircraft mechanics (17:2). Third, the Combat Command organized the men and planes in the combinations required to support its four Air Forces. Each of the four Air Forces of the Combat Command was composed of a Bomber Command, an Intercept Command, a Support Command, and a Base Command, which normally controlled the engineers (17:2). The War Department recognized that the aviation engineers were vital to the Army Air Forces and created an engineer component on the General Headquarters (GHQ) staff of the Army Air Forces in 1940 (95:10). While the Air Engineer of GHQ, AF, was to monitor all aviation engineer functions, the Operational Division of the War Department General Staff controlled the assignments of aviation engineer units (39:244). The only way the Air Engineer could influence the aviation engineers was through such means as the recurrent publication of the "Aviation Engineer Notes," personal inspection tours, and correspondence direct to the units in the field (39:244). The Air Engineer and the AAF top leadership argued throughout WWII that the Air Force, and not the Army or Navy, should control the aviation engineers.

One of the AAF major concerns was the assignment and employment of aviation engineers. At the beginning of WWII aviation engineers were assigned in a "piece-meal" manner by the Operational Division (39:245). The aviation engineers

were pooled with Army and Navy construction forces and were assigned to the most urgent work without regard as to whether the work was support of AAF requirements or whether the aviation engineers were efficiently employed (i.e., building bridges and dams versus airfield facilities) (39:245). However, because the theater Commander had the final say on the employment of the forces within their Theater of Operations, the aviation engineers were employed and controlled in varying manners throughout WWII. The two most common organizational controls and employment of aviation engineers was through the Supply of Services or through a theater engineer command (146; 193:TAB B-3).

The employment of the aviation engineers in the European Theater of Operations (ETO, limited to the United Kingdom at start of WWII) during the early years of WWII was controlled by the Army's Services of Supply (SOS). In fact, the Eighth Air Force got very little say in any construction matters. The SOS controlled all construction matters in the United Kingdom, allowing the Eighth Air Force some say in the planning and supervision of construction. The primary responsibility/authority of Eighth Air Force was training of the aviation engineering units for the rapid construction and combat techniques which would be needed for the invasion of Normandy (96:1-2; 39:242-245). Although the British Air Ministry was providing the majority of the construction resources for American airfields in the UK, the

aviation engineers were fully employed on airfield construction and other duties as directed by the SOS (95:1). As a result, the SOS allowed the aviation engineers only one hour per day for combat training (96:3). The Eighth AF, while recognizing that the SOS was doing a relatively good job of employing the aviation engineers, complained that the aviation engineers were not being properly prepared for the rapid construction and combat that would occur in the forthcoming invasion of the European Continent (95:1-2). Eighth AF was also concerned about the aviation engineers being used to perform non-construction duties such as loading and unloading ships (96:2). The Eighth AF wondered where the aviation engineers would be when an airfield must be built in a forward area to support the invasion of France. Would the aviation engineers be loading ships or building a bridge? Eighth AF considered the SOS control completely unsatisfactory.

While planning for the North African Campaign in the Mediterranean Theater of Operations (MTO), the aviation engineers had the opportunity to establish themselves as the sole responsibility agent for airfield construction. In 1942, the American Field Service Regulation did not specify what agency would be responsible for airfield construction in a theater of operations (45:2). A decision had to be made as to whether the Army Ground Forces or the Army Air Forces would be responsible for airfield construction (45:2). The Army argued that because this would be an

Allied operation with the British and the British Army did all airfield construction for the RAF, all American airfield construction should be done by the Army to keep things standardized (45:2). The Army also contended that airfield construction and construction for the ground forces would inevitably be competing for the same resources. The Army Air Force argued that airfields were essential in the projection of airpower, and in order to ensure the specific airfield requirements of the Air Force were satisfied, the 12th Air Force should be given control of all airfield construction (45:3). The 12th Air Force would be responsible for all rear area airfield construction (45:3). While the Air Force had won the battle for American airfield construction in the rear areas, all requests by the Eastern Air Command for forward airfields had to, first, go through the Chief Engineer of the First Army (45:6).

Requesting forward airfields through the First Army was not the only organizational problem experienced by the 12th AF engineers. At the beginning of the North African Campaign the 12th AF Hq, 12th Air Support Command, and the 12th Air Force Service Command all had engineering sections (45:6). The Headquarter Operational and Planning Section was the first agency to recognize and specify airfield requirements. Although the Air Engineer of the 12th AF had the most direct lines of communication with the Operational and Planning Section, the Air Force Service Command controlled all aviation engineers (45:6). The 12th AF Engineer

tried to gain direct control of the engineers. These proposals were officially refused, but three actions were taken to make this organizational system work.

First, the 12th AF Engineer was given command of the 12th Air Force Service Command, thereby consolidating the two headquarters (45:6). Second, the Commanding General of 12th AF made the 12th AFHQ/12th AF Service Command Engineer responsible for all airfield construction (45:6). Third, the Air Engineer for 12th AFHQ was given direct control over all aviation engineer taskings (45:6). Although the 12th AFHQ Air Engineer was directing all aviation engineers and the Air Force was taking more responsibility for forward airfield construction as the North African Campaign progressed, administrative and organizational problems persisted.

The problem developed when the aviation engineers and the Service Command adopted a system of area responsibilities (45:7). Conflicting orders from the Air Engineer and Area Service Commanders confused and disrupted the work of aviation engineers (45:7). For example:

> In one instance the officer in charge of a job received orders from his Area Engineer (confirmed by Engineer, 12th Air Force), the tactical commander in the area, the Commanding General NAAF, and the Service Area Commander within the same day. The orders conflicted, and as a result work was started, stopped, undone, started another way, stopped, changed until thoroughly bewildered, the officer in charge stopped all work while he signaled the Engineer for instructions (45:7).

Clearly, the fact that the Air Engineer had to publish all assignments through the 12th AF Service Command weakened his

authority and clouded the exact command and control system of the aviation engineers. As illustrated above in the previous quote, loyalty of aviation engineers to the Engineer, 12th AF helped to make things work a little better (45:8).

During the rapid advance into Tunisia in late November and early December of 1942, the senior Engineer officer in any particular area was designated as the person in charge of all aviation engineers in that area; the senior engineer answered only to the senior Air Force Tactical Commander in that area (45:7). This organizational system appeared to work well and was continued throughout campaigns in North Africa, Sicily, Italy, Sardinia and Corsica (45:7). Finally, on 26 October 1943 the 12th Air Force Engineer Command Provisional (AFEC (Prov)) was created by General Order 74, Headquarters, 12th Air Force. The AFEC (Prov) was later redesignated in April 1944 as the AAF Engineer Command, Mediterranean Theater of Operations (MTO), (Prov). (45:7, 194; TAB B-4)

The establishment of the Engineer Command reduced and/or eliminated many organizational and operational problems for the MTO aviation engineers. First, an official and streamlined command and control system, which reduced the time required to turn plans into action and specifically dictated who would control the aviation engineers, was established (45:8). Before the AFEC (Prov) was established, conflicting orders (as already described), long and

complex lines of communications between the requesting agency and the Services Command, and the employment of aviation engineers on work not related to airfield construction limited the airfield construction capability of aviation engineers.

The formation of the AFEC (Prov) also helped to reduce the supply and equipment problems which confronted the MTO aviation engineers. The problem of supply and equipment is described in the following quote from a report titled "A History of Policies Affecting Aviation Engineers in the Mediterranean Campaigns":

> . . . The further down in the deck you are the less attention is paid to your needs . . . In his capacity as Engineer, Air Force, rather than Engineer Service Command, the Engineer was able to bring the most urgent needs for pierced steel plank and asphalt to the attention of the Air Commander in Chief and thus secure command decisions as to allocation of tonnage between these items bombs and gasoline (45:8).

The effectiveness of Air Force control and the eventual establishment of the AFEC (Prov) is reflected in the aviation engineer track record in the MTO. During the North African Campaign, the aviation engineers built 127 airdromes (39:253). The combined efforts of the British engineers and the American aviation engineers resulted in a completed airfield every two days (45:1). This effort brought praise from Major General Carl Spaatz, Commanding General of the Northwestern African Air Force (NAAF). General Spaatz wrote that the aviation engineers were "as

nearly indispensable to the AAF as is possible to ascribe to any single branch thereof" (39:25). The AAF had proven it could effectively control the work of the aviation engineers.

European Theater of Operations (ETO). The 12th Air Force AFEC (Prov) was not the only Engineer Command established during WWII. As previously mentioned, the aviation engineers in the United Kingdom (UK) were under the control of the Supply of Services of the Army. The 8th AF had been unable to gain control of the aviation engineers despite repeated efforts. Eighth AF had two points of contention about the SOS's control of the aviation engineers. First, 8th AF felt that the aviation engineers were not being properly prepared for rapid construction and combat situations that would be experienced in the event of an Allied invasion of the European Continent. Second, 8th AF argued that processing all airfield requirements through the Army's SOS would increase the time between identification of airfield construction requirements and the start of the construction (95:1-2). This situation would severely restrict the AAF from responding quickly to rapidly changing situations which were expected in an Allied invasion of Europe. Eighth AF pointed to the success of the AFEC (Prov) and to a directive issued by the War Department on 26 August 1943 which stated:

> 1. In some theaters the Operating Air Force has been divested of essential components provided by the War Department and of certain vital activities, installations, and facilities which should be closely integrated into its operations. This practice has been most general in the improper assignment of Aviation Engineer troops and the responsibility for airdrome construction.
>
> 2. Aviation Engineer units, and other units of the Army and Services with the Army Air Forces, are organized and trained for employment with the Air Forces in combat theaters. Consequently, the normal employment of these units is in an assigned status with the Air Force. Similarly, the responsibility for the functions which these units are designed to fulfill is one pertaining to the Air Forces and should be so assigned (1:1).

While the first two paragraphs clearly state that the aviation engineer should be assigned to the Air Force to work on airfield related construction, the third and final paragraph leaves the final control of aviation engineers to the theater commander.

> 3. Nothing in the foregoing will be interpreted to restrict the authority of the theater or similar commander in making such adjustments of organization and employment of his forces as may be required to meet conditions peculiar to his theater (1:1).

General Lewis Brereton, who played an important role in the establishment of the 12th AFEC (Prov), knew the importance of the AAF directly controlling the aviation engineers (39:245). After being assigned as the Commanding General of the Ninth Air Force which would accompany the Allied Forces in the invasion of Europe (Operation OVERLORD), General Brereton began pushing for an Engineer

Command comprised of the aviation engineers in the UK. (39:265-266) The formal establishment of an Engineer Command in England was disapproved by the War Department, as it was afraid other agencies would use this precedent to elevate their own status (39:266). The theater commander, however, exercised his powers to establish a provisional engineer command and on 30 March 1944, the Ninth Air Force received authority to establish the Ninth (IX) Engineer Command. (39:266) In May of 1944, sixteen battalions and four regiments (less three battalions) were transferred to the IX Engineer Command (194:TAB 13-1).

The aviation engineers of the IX Engineer Command were heavily involved in the liberation of Europe from D-Day to the surrender of Germany (39:267). In less than one year, the engineers of the Engineer Command had constructed or repaired at least 241 airfields from Normandy to Austria (39:274). The AAF engineers were not the only ones who believed that the organization of aviation engineers into an Engineer Command was the most effective system of controlling aviation engineers. Major General Cecil R. Moore, the Chief Engineer (Army) of the European Theater of Operation, stated that:

> . . . the employment of Aviation Engineers under Air Force control was sound, was the happiest solution of the mutual responsibilities for construction, did not provoke conflicts in the supply problem, and he advocated an equivalent organization for the Ground Forces (194:TAB B-5).

Pacific Theater. Although the Engineer Commands of the 12th and IX Air Forces proved effective in the command and control of aviation engineers, the aviation engineers in the Pacific Theaters were assigned to and controlled by the theater commanders. This meant that the aviation engineers were under Army or Navy control (39:245). Aviation engineers working in the Pacific Theaters also found themselves subjected to varying command (39:276). For example, the 808th Engineer Aviation Battalion (EAB) was reassigned to various commands seven times in less than two years.

In the South Central and North Pacific areas, the aviation engineers were controlled by the Navy (39:276). In the Pacific Ocean Area (POA) the aviation engineers were administratively under the Army Air Force of the POA (160:TAB G-2). To obtain supplies and materials, however, the aviation engineers had to depend on Army garrison forces (39:304). Finally, while island commanders had operational control over the aviation engineer units (160:TAB G-2), CINC POA, Admiral Nimitz, exercised ultimate control over the aviation engineers, particularly in important matters (39:304).

While AAF senior leadership would have preferred direct control of the aviation engineers through an Engineer Command, they recognized that Island operations in the POA necessitated the existing organization and control of the aviation engineers (160:TAB A-2). Also the employment of aviation engineers in the POA was "consistent with its

manning, equipment, and training" (160:TAB F 1-2). This was not the situation in the Southwest Pacific Area (SWPA) where the aviation engineers were assigned tasks based on the urgency of the work. Very little consideration was given to matching the capabilities of the aviation engineers to the work or to whether or not the work was related to airfield requirements (160:TAB F 1-2).

In the SPWA, aviation engineers were generally assigned to the U.S. Army Services of Supply (USASOS) (160:TAB A 1-2). The control of the aviation engineers was shifted occasionally between the Sixth Army, the Eighth Army and the Far East Air Forces (FEAF) (160:TAB A 1-2). Eventually, however, the aviation engineers would always return to the USASOS (160:TAB A 1-2). The aviation engineers had been pooled with the General Service Engineers and Engineer Construction Battalions and as previously mentioned were "considered equally available, despite a nonparity in equipment, specialized personnel and training for all types of engineering work" (160:2). General MacArthur had considered it necessary to place all engineers and construction forces under General H. J. Cassey, Chief Engineer, General Headquarters (GHQ), Southwest Pacific Army, to better control the construction resources (men, equipment, supplies and materials) (39:277; 160:2). It was also considered advantageous to have a single person/agency to control the engineering support needed during the "island hopping" operations common to the SWPA (160:2). Island hopping

operations consisted of capturing an enemy held island, establishing an expedient airfield for fighter aircraft by repairing captured airfields or constructing a new airfield so that air cover could be established, and then improving the airfield to support bomber and cargo aircraft which were needed to build-up for the next island hopping operation.

Fifth Air Force was dissatisfied by the USASOS control and employment of aviation engineers. They argued that airfield construction would have been more effective and efficient under their (5th AF) control (95:6). Fifth Air Force contended, as did many senior aviation engineers, that the pooling method was not the most efficient and effective use of the unique skills, equipment and organization of the aviation engineers (160:TAB G-1). The AAF engineers also felt that:

> . . . few if any of the various echelons of command and administration had had any experience with or appreciation of engineer construction and the essential role played by it in modern war (41:4).

The AAF engineers argued that the constant shifting between the Sixth Army, the Eighth Army, the FEAF and USASOS had made it difficult, if not impossible, for the shifting aviation engineers to receive critical supplies. Col Mayo in his report on the status of aviation engineers in the Pacific Theaters wrote:

> Requisitions for plant or supplies submitted under one control were automatically canceled when the control was changed. One unit had worked under three controls on a single job. The unit got to

> feel that it was "nobody's baby." The Aviation Engineers felt in SWPA that they had no one agency who was interested in their well being and to whom they could appeal (160:TAB E-3).

Colonel Mayo also reported that USASOS control and the changing of control had adversely affected the morale of the aviation engineers (160:TAB G-1). Colonel Mayo contended that the morale problem was worsened by the fact that aviation engineers were required to work on tasks not related to airfield requirements such as the construction of roads, bridges, hospitals and depots (160:TAB A-1). Mayo's report also stated that General Service Regiment which were not a equipped or trained for airfield construction were often tasked to perform demanding jobs such as the construction of a runway (160:TAB A-1).

<u>Employment of Aviation Engineers</u>. Employment of aviation engineers on work not related to airfield/Air Force requirements was a constant point of consternation for senior AAF leadership and aviation engineers throughout the theaters of WWII. For example, during the Philippine campaign, aviation engineers spent more than half their time and resources on non-Air Force work (39:291). The 842nd Engineer Aviation Battalion (EAB), which was assigned to SWPA, spent only about one-tenth of the total time performing airfield construction (39:281). The 842nd EAB directed most of its efforts toward the construction of 25 miles of road between the harbor at Lae and the bases at Nadzabon, New Guinea (39:281). During the invasion of

Italy in September 1943, the 817th EAB was required to service airplanes (refuel and rearm the aircraft) the day after they had completed a 4,000 foot earth runway at Salerno (39:258). At Licta, Sicily the 815th EAB also had to refuel and rearm aircraft after preparing initial airfield surfaces and facilities (39:255). It seemed to the aviation engineers that they were forever doing someone else's (Army's or Navy's) work and they disliked assignments to construct roads, port facilities, oil storage systems, prisoner of war facilities and storage depots (39:257, 290). In all fairness, though, it must be said the Army Engineers and the Navy Seabees were tasked and did accomplish airfield construction projects (39:290; 95:7-8).

Aviation Engineer Units and Their Responsibilities. Before terminating this section on the control, employment and organization of aviation engineers, a brief description of the primary aviation forces and their primary duties will be presented. The following descriptions were taken from AAF Training Standard No. 40-8-1, 20 January 1943 (237:1-2). Authorized strengths shown in brackets were taken from prepared lecture notes on the "Function and Mission of Aviation Engineers". There was no date on this document. The numbers of these organizations also varied throughout WWII. The manpower figures should, therefore, be considered to be approximate.

> Engineering Aviation Battalion. This is the basic construction unit of an air force. Its mission is to construct and camouflage an

airdrome with all its appurtenances in a theater of operations and to assist in its defense. The battalion is charged with the maintenance and rehabilitation of an airdrome or airdromes, including maintenance under enemy attack (39:1). [The authorized strength was 31 officers and 766 enlisted men (80:4).]

Engineer Aviation Regiment. This unit is designed for operations in a large theater of operations where a great volume of engineering work is concentrated in a relatively small area. Its basic mission are identical with those of engineer aviation battalions (39:1). [Authorized strength of engineer aviation regiments was 112 officers and 2585 enlisted personnel (80:5).]

Engineer Aviation Company. [The normal mission of this unit is to maintain an airdrome and all of its appurtenances, to assist in its defense, and to demolish its facilities in the event of abandonment (39:1). Authorized strength of this unit was 5 officers and 178 enlisted personnel (80:5). Engineer Aviation Companies could operate alone only on small projects (80:5).]

Engineer Air Force Headquarters Company. This unit is normally attached to an air force headquarters. Its mission is to assist the engineer sections of the air force in the location planning, and camouflaging of new airdromes, making preliminary surveys thereof, to furnish clerical, drafting, engineering, and camouflage assistance in connection with the operations of engineer aviation regiments and battalions operating under the air forces; and to reproduce and distribute standard aeronautical charts (39:1-2). [Authorized strength was 12 officers and 213 enlisted men (80:4).]

Engineer Aviation Topographic Company. This unit operates in conjunction with the Army Air Forces Mapping Group in solving the immediate mapping and charting problems of an air force. Its primary mission is to obtain new horizontal and vertical control; to maintain, prepare, reproduce, and distribute special information required by combat aviation (39:2). [Authorized strength of this unit was 8 officers and 147 enlisted personnel (80:5).]

Engineer Aviation Camouflage Battalion. This unit furnished technical assistance, supervision, and control for the camouflage activities of all Army Air Forces units in a theater of operations in connection with the design, planning, and execution of their camouflage works. It fabricates and supplies camouflage materials from local sources when the situation calls for such operations. It carries on experimentation for new camouflage methods and is responsible for the indoctrination and training of all Army Air Force units in a theater of operations in connection with camouflage policy, discipline, practices, and techniques through the medium of schools and field demonstrations, by preparation and dissemination of publications and posters, and by other similar means (39:2). [Authorized strength was 32 officers and 557 enlisted men (80:5).]

Engineer Airborne Aviation Battalion. The mission of this unit is to construct or repair landing facilities rapidly where air movement or beach landing operations are involved. This will include the rehabilitation and maintenance of captured facilities for the rapid use of Army Air Forces combat units. These operations may be behind enemy lines initially. Removal of obstacles and mines are also missions of this unit (39:2). [Authorized strength of this unit was established as 29 officers and 501 enlisted men (80:8).]

Engineer Aviation Maintenance Company. [This unit was authorized 6 officers and 188 enlisted personnel. Primary mission was fourth echelon maintenance of engineer equipment (80:5).]

Engineer Aviation Depot Companies. [The mission of this unit was to handle, store, and distribute engineer equipment, supplies, and construction materials. [Authorized strength of this unit was 6 officers and 188 enlisted men (80:5).]

The primary aviation engineer unit during WWII was the Engineering Aviation Battalion (39:240; 237:1). Each EAB was authorized over 220 pieces of equipment and was supposedly organized for 24-hour per day operations (39:240; 97:34). The EABs were authorized approximately 220 pieces

of what was considered the most advanced "state of the art" heavy and ordnance equipment (39:240). The EABs were considered an excellent and very capable construction force.

Airborne Aviation Engineers. Although the EAB was the primary aviation engineer construction force, the Airborne Aviation Engineer Battalion provided a unique construction capability. Brigadier General Stuart C. Godfrey, the Air Engineer, GHQ, AF, conceived the idea of a specially trained and equipped aviation unit which could be transported by air to construct or repair airfields behind enemy lines or near the front lines, which would be inaccessible to the standard EABs and their heavy equipment (15:1). The Airborne Aviation Engineers and their equipment would be transported by C-47 or a combination of C-47s and CG-4A gliders to a selected airfield site which was inaccessible to regular EABs (15:7-8). They would then use their air-transportable equipment to make minimum repairs on a captured airfield or construct an expedient airfield to support fighters and heavier transport aircraft (15:7-8). The airborne aviation engineers were also to have the capability to defend the airfield until ground forces could be brought in (15:4, 169:1).

Because the airborne aviation engineer units were to be air-transportable, the size of the unit (530 personnel) would have to be less than a standard EAB (797 personnel). The weight constraints of 3,200 pounds for a glider and 4,500 pounds for the C-47 limited the weight and amount of

equipment (169:1). The dimensions of any equipment or supplies were also limited to a height of 60 inches and a width of 80 inches (169:1). Two options regarding equipment were considered (169:11). Initially, it was thought that regular EAB equipment could be disassembled, loaded on the gliders and aircraft and re-assembled at the selected airfield site (15:11). This concept proved impractical because of required modifications, disassembly, and, more importantly, because of re-assembly time (169:11). The second concept, which was adopted, was to manufacture miniature versions of standard EAB equipment.

On 18 August 1942, the Adjutant General, War Department, directed the First Air Force to activate the First Provisional Airborne Engineer Aviation Battalion (169:2). Extensive training of the airborne aviation engineers took place at Westover Field, Massachusetts (169:2). On 8 October 1942, two airborne aviation companies left Westover Field and headed for North Africa (169:5). Just six months after the original conception of airborne aviation engineers, two companies of airborne aviation engineers landed with the Western Task Force on the beaches of Africa on 8 November 1942 (169:3). Their initial indoctrination was combat and not construction (169:3).

There were several occasions where the airborne aviation engineers were effectively employed to provide expedient airfields. The first and probably most publicized

use of airborne aviation engineers occurred in North Africa on 13 December 1942 (39:25; 26:2). Two companies of the 871st Airborne Engineer Aviation Battalion were transported to Youks-les-Bains in central Tunisia. From there, the two companies split up. Company B went to Biskra and Company A marched to Tebessa (238; 193:5). Within 24 hours, an earth runway capable of supporting B-17s was constructed at Biskra (39:250). Company A had the Tebessa airfield ready for P-38s in four days (238; 193:5), while Company B had Biskra fully operational in three days (238; 193:5). At Marilinas (Tsili-Tsili) in New Guinea, the 871st Airborne Aviation Engineers built two earth runways, 6,000 and 4,500 feet long, and 70 hardstands using their miniature equipment in three weeks (95:6).

On 5 March 1944, the airborne aviation engineer accompanied commando troops behind enemy lines in Burma where they built the first airfield behind enemy lines in just 24 hours (98:5-7). Air Marshall Baldwin wrote in a report to Major General George E. Stratemeyer, U.S. Army, Commanding General, Eastern Air Command, that "Wingate . . . (British Major General Orde C. Wingate, who led this commando operation) . . . and I think you should tell Godfrey that his airborne engineers are superb, repeat superb" (98:7).

Even with these and a few other successful employments of airborne aviation engineers, many AAF senior leaders felt that the airborne aviation engineers were not needed/employed enough to justify their existence as a separate

permanent aviation engineer unit. The skeptics also contended that the miniature equipment of the airborne aviation engineers was not only too light for the airborne operations; it was also too light for normal aviation engineer construction assignments (39:280-281). The airborne aviation engineers were indeed employed only a few times. In many cases, their equipment was shown to be too light and required extensive maintenance (105:1). Between employments on special missions, the airborne aviation engineers were assigned to normal construction and maintenance activities where their equipment was almost always ineffective. By late 1944, the airborne aviation engineers were given heavy equipment so they could supplement the EABs in the theaters (39:281).

One must remember that, while the miniature airborne engineer equipment was not as substantial as the standard EAB equipment and the airborne aviation engineer units were smaller than the standard EAB's, the original mission of the airborne aviation engineers was limited to the "initial preparation" and "maintenance and repair" of advanced airfields (15:7-8).

Construction Achievements and Problems

Achievements and Capabilities. Although the aviation engineers were constantly battling inefficient organizational and employment policies, and logistical and technical

problems, their accomplishments and demonstrated capabilities were remarkable. As previously mentioned, the aviation engineers were involved in the construction and repair of 127 airfields in North Africa and 241 airfields in support of ETO operations. The aviation engineers in conjunction with other construction forces built and repaired over 200 runways and countless supporting facilities in the Pacific Theaters (41:6).

The build-up of airfields by the aviation engineers was rapid. In November of 1942, there were only nine airfields in North Africa. During the period from 8 November 1942 to 31 August 1943, the aviation engineers of the Mediterranean Theater of Operations had constructed the following types and quantities of airfields (207:1):

Table I

MTO Aviation Engineer Accomplishments
November 1942-August 1943

	Northwest	Sicily and other islands
Dryweather		
Constructed	75	14
Improved	20	4
Hard Surface		
Constructed	22	--
Improved	6	6
	123	24

The capability of the aviation engineers to rapidly construct airfields was demonstrated in the Sbe- -la sector of North Africa where five airfields were constructed in just

72 hours to support the rapidly advancing allies (18:22). MTO aviation engineers gained the admiration of Allied senior leaders such as Air Chief Marshall Tedder when a single company of aviation engineers constructed a fighter airfield on the rocky island of Gozo in just two weeks (95:2).

The accomplishment of the ETO aviation engineers was just as spectacular. During the period from D-Day to 27 September 1944, the engineers of the IX Engineer Command built 98 airfields in Western France (12:4). The number of constructed or rehabilitated airfields increased to 119 by 15 November 1944 (12:4).

In the Pacific Theater, the ability of the aviation engineers to rapidly construct airfields was cited by Major General William E. Lynd, Commanding General, Fourth Air Force, as a major military advantage held by the U.S. over the Japanese (156:2).

The capability of aviation engineers to construct and repair airfields varied greatly because of terrain, climate, availability of equipment, supplies and labor, and military situation. It was estimated that recaptured airfields could be repaired by an EAB in one day (95:11-12). Earth runways were prepared in Africa in approximately three days (95:11-12). Runways with prepared sub-bases and PSP surfaces, such as the airfield at Bone in Africa which had a 6,000 foot runway, took as little as two weeks to construct (95:11-12).

European experiences indicated that six weeks were needed to construct similar runways (94:3). The large concrete runways in England required the efforts of an EAB for about 8 to 10 months.

Estimates for airfield construction based on sizes of aircraft in the SWPA indicate that it took 20 days for eight fighter aircraft, 30 days for medium weight aircraft, and 40 days for heavy aircraft (160:10). Concerning maintenance and repair of airfields, it was estimated that a battalion could repair and maintain as many as nine airfields (97:36). As previously mentioned, the construction time varied greatly because of many factors and/or problems encountered by the aviation engineers.

Problems of Working Environment. Technical practices during WWII were considered to be governed by five factors: (1) mission, (2) military situation, (3) climate, (4) geology, and (5) nature and adequacy of transportation (194:6). Without a doubt, these factors did, as they do today, influence the construction techniques used by Army Air Force agencies during WWII. Unfamiliar climates, soil conditions, topography and vegetation resulted in many unpredicted problems for the aviation engineers.

When aviation engineers arrived in North Africa, they encountered serious problems with rain and the subsequent mud (214:4). After the rains stopped, usually in early March, the aviation engineers faced another formidable

problem in the form of dust (238; 193:2). Brigadier General Davison (earlier identified as Colonel Davison), the first commander of the 21st Engineer (Aviation) Regiment, once wrote as the Chief Engineer of the Northwest African Air Forces that ". . . we came to look upon mud rather than the Axis forces as our enemy" (26:1). The rain and climate combined in North Africa to promote malaria, cold, and other sicknesses that would continue to be experienced throughout the European War (214:4). Malaria was considered the major problem in North Africa (214:4).

Elsewhere in the MTO, rain, high water tables and topographical conditions created difficult drainage problems for aviation engineers (214:30). On the Foggia plains in Italy, the water table was reported to be only a few feet below the ground surface (214:30). Drainage problems plagued aviation engineers in all theaters of operation during WWII. The tropical weather in the Pacific Theaters produced heavy rainfall such as the 75 inches which was once recorded at Finschafen over a three month period (160:TAB F-2). These heavy rains required aviation engineers to give special consideration to drainage structures. The constant rains combined with the clay-type soils and flat low lying terrain of England also created difficult drainage problems for aviation engineers (95:2).

While the aviation engineers were well aware of the need for adequate drainage, the lack of proper drainage caused more airfield pavement failures and difficulties than

any other single factor (142:11). Numerous airfield pavement failures in Great Britain resulted because adequate drainage facilities could not be installed during the initial construction phase due to wet winter weather (11:16). It was estimated that the completion of 30% of airfields in the ETO and MTO were delayed one to three weeks because drainage control was not properly considered during the early stages of construction (194:TAB G-11). Many memorandums, manuals, specifications, directives and official publications were issued to field units to try and combat the inattention to drainage (142:11). One such memorandum from the Chief Engineer, SWPA, stated:

> 1. Although the problem of drainage has been repeatedly stressed, it is apparent from personal observation on numerous recent inspections that the importance of drainage is not adequately appreciated nor understood by many engineer headquarters and units.
>
> 2. FAILURE TO PROVIDE ADEQUATE DRAINAGE AS ONE OF THE EARLIEST FEATURES OF ANY CONSTRUCTION PROJECT INDICATES A BASIC LACK OF ENGINEERING KNOWLEDGE . . . (40:1)

There were many reasons for the absence of drainage consideration. First, in many cases, the necessity to rapidly construct an airfield (to support immediate operational needs) required that necessary extensive site selection procedures and drainage construction be curtailed or completely eliminated (41:13). Secondly, there were no established rainfall/groundwater flow algorithms for accurately determining and sizing drainage structures for the heavy rainfalls experienced in many theaters (41:13).

The lack of records on rainfall prevented/reduced effective advance planning (41:13). Finally, in many cases, as suggested above, many aviation engineers lacked the needed "ENGINEERING KNOWLEDGE."

Dust control also proved to be a major problem. In addition to causing excessive wear of aircraft parts, dust clouds delayed take-offs and created hazardous airfield conditions (71:8). Another imperative reason for dust control was to prevent the erosion of the sub-base, which if not prevented, would lead to the failure of the airfield landing surface (71:8).

The rain-forests, jungles and coconut groves of the Pacific Theaters, particularly in New Guinea, caused the aviation engineers many problems and delays (95:7; 41:11-17; 26). At first aviation engineers attempted clearing operations which paralleled lumbering operations (41:12). The felling, cutting, loading and hauling of the jungle trees was too time consuming (41:12). By using bulldozers and winches, the aviation engineers were able to uproot and remove large trees more efficiently (41:12). Another major problem of constructing airfields in the rain forests and coconut groves of the Pacific Theaters, was the removal of humus type soil (decayed vegetation) which could not support the weight of aircrafts (41:16).

Operations in Arctic conditions also required removal of highly unstable soils. Removal of the tundra soils in the Aleutian Islands delayed airfield construction as

excavations of six to eight feet were required (84:4-5). The Aleutian winds which had been recorded as high as 135 miles per hour and the freezing Arctic temperatures severely restricted work (242:9). Winds of 70 miles per hour were known to literally roll-up unanchored PSP (242:9).

Many of the remote and isolated locations, where airfields had to be constructed, presented extreme hardships for the aviation engineers. Working in areas without locally available supplies, labor forces, and utilities and transportation systems greatly delayed airfield construction (95:4-10). The construction of airfields in remote locations provided military strategists with a very important "lesson." The assumption that there would always be an ample supply of locally available labor for airfield construction was proven false in the islands of the Pacific, the deserts of North Africa and the jungle of New Guinea (39:243). The premise of an always abundant labor supply from the "civilized work" was a major road block to establishing an adequate aviation engineering force (9; 193:TAB 13-4-5).

Even in well populated areas, there were many problems with employing civilian labor. In France, the available civilians were either very young or very old as the prime-aged civilians were either dead or engaged in combat (39:264). The aviation engineers also had problems in hiring individuals or contractors because many were in bad

standing with the French Underground (39:264). The Filipinos after recovering from the Japanese occupation were able and willing laborers. However, they caused many security problems by pilfering supplies and small equipment items (39:291-292). In China and India, the cultural and language barriers proved formidable obstacles to the construction of airfields (14:32,43). Because there always seemed to be a labor shortage and a pressing need for airfields, the development of labor-saving and time-saving items such as portable landing mats were essential.

Landing Mats and Other Time Saving Developments. One of the primary areas of aviation engineering research and development prior to and during WWII concerned the development of landing surfaces or mats for aircrafts. During WWII, a heavy mat was needed for bombers and a lighter mat was needed for fighter aircraft (17:4). By October 1947, the Corps of Engineers had developed the following four types of expedient airfield mats.

1. Pierced Steel Plank (PSP) (heavy)
2. Irving Grid (heavy)
3. Rod and Bar (both heavy and light)
4. Sommerfeld Track (light) (19; 170:42)

According to a 4 January 1944 report written by General Arnold to the Secretary of War, "The portable steel landing mat (PSP) used in all theaters has been one of the outstanding developments of the war" (18:22). By 4 January, 175 million square feet of PSP had been sent to the various theaters and another 300 million square feet ordered

for 1944 (18:22). PSP consisted of 15 inch wide by 10 foot long planks of pierced steel which weighted 65.63 pounds per plank (18:22). Reports from the field indicated that PSP was the most preferred and most durable of the expedient airfield surfacing materials (85:7-8). While PSP was the most durable and preferred airfield mat, there were many problems associated with PSP.

A primary problem with PSP was its weight and tremendous bulk, making it difficult to store and transport to remote locations via already overtaxed lines of transportation. The PSP required to provide a 150 foot wide by 5,000 feet long runway would weigh 1988 tons and require 35,000 cubic feet of cargo space (49:43).

While PSP could be laid on unprepared bases (i.e., laid directly on ground provided the surface was flat enough to permit aircraft operations), the recommended procedure called for extensive initial preparation and continued protection of the supporting base for the PSP. Without this extensive base preparation and continued protection and maintenance, the PSP would eventually fail. One of the most common problems was the erosion of the base by water or by wind. Rainwater would pass through the openings of the PSP and weaken the sub-base. As aircraft traveled over the weakened sub-base, the sub-base would be depressed (rutted), thus, creating a collection point for more water. When the depression grew big enough, the PSP would flex. The constant flexing of the PSP would in turn "pump" more base

material through the openings, thereby, creating a larger depression. Eventually, the PSP would fail (41:110; 104:2). Once the PSP had been damaged, the bad section had to be disconnected (usually by cutting), the individual pieces were rehabilitated (estimated that approximately 80% of bent and warped PSP could be rehabilitated) (201:15), the sub-base was repaired, and the PSP was replaced. Preventive maintenance techniques such as raising portions of the PSP mat while intact and brushing sand or some similar base material through the openings were used to fill in minor depressions before they became too large and caused the PSP to fail. Placing a light mat over the base, spraying the base with asphalt or injecting chemical soil stabilizers into the base before baying the PSP mat were somewhat effective in reducing erosion and failure of the base material (160:8; 48:18).

As mentioned, the PSP was very heavy and bulky. Relative to many expedient runway surfacings, PSP was also very labor intensive and very time consuming. Therefore, during the invasion of France, the primary expedient runway surfacing materials were Prefabricated Bituminous Surfacing (PBS)/Hessian Surfacing or Square Mesh Track (194:7; 12:4). These materials were lighter, required less logistical support (i.e., took less cargo space and easier to handle) and were easier to install than PSP (12:4).

Prefabricated Bituminous Surfacing (PBS), which was sometimes called "Bitt Hess", was composed of hessian cloth,

burlap or some other heavy cloth and paper felt bounded together and impregnated with asphaltic compounds (43:45). A 150 foot wide by 5,000 foot long PBS runway weighed approximately 344 tons compared to the 1988 tons of the same runway of PSP (43:4-5). It took approximately one man hour to lay 185 square feet of PBS (43:4-5). PBS laid over a well compacted 12 inch base could support wheel loads from 7,000 to 15,000 pounds. However, because PBS had no load carrying capability itself, it would fail immediately upon base failure (196:2). Extreme temperatures could also lead to deterioration of the PBS. At temperatures above 90°F, the asphaltic compound which held the PBS together would begin to melt (196:2). At temperatures below 32°F, the PBS would become very brittle and break (196:2). Locked wheel turns by taxing aircraft would also cause severe rips in the PBS (194:TAB G-2). Although constant maintenance was required to keep the tears and holes in the PBS repaired, the repairs of PBS were simple and a crew of 20 men could keep a PBS runway in "first class condition" (194:TAB G-4). In many cases, the PBS was used in combination with PSP and Square Mesh Track.

Square Mesh Track (SMT) was really nothing more than a heavy wire mesh and weighed about 613 tons for a 150 foot wide by 5,000 foot long runway (49:43). Very similar to SMT was the Sommerfeld mat. Sommerfeld mat was a heavy wire netting with 3/8 inch diameter mild steel bars running through the netting at eight inch intervals (153:40;

171:21). While the Sommerfeld was used a few times by aviation engineers, it was not considered a very favorable expedient airfield surfacing material (238:3).

Many other landing mats were developed and tested during WWII. For example, the Engineers Board experimented with the use of wooden runway mats made with 2x4s nailed together in a staggered or blocked pattern (243:12-18). A runway 150 feet wide by 5,000 feet long required two million board feet of 2x4s and 380 kegs of 20d nails (243:12-18). Because the wood runway was to be laid directly on the ground, it was to be treated to prevent decay and insect infestation (243:12). The authors did not find any records of the use of wood mats in combat theaters. In fact, as WWII progressed, PSP became the primary expedient airfield surfacing material.

Soil stabilization was needed on all airfields, regardless if it was an earthenway, a PSP runway, or a hard surfaced runway (i.e., cement or asphalt) (41:21). Soil stabilization techniques ranged from using locally available vegetation (i.e., straw, coconut palms, leaves, etc.) to asphalt, to soil cement, to specialized chemical stabilizers (vinsol, compound No. 321 and Stabinol) to saltwater, and even to using molasses and bitumen compounds to prevent/reduce water infiltration and water absorption of the soil (41:21). More stable soils meant fewer maintenance problems, less airfield failures, and greater load carrying capabilities of airfield.

The use of locally available material for airfield construction reduced the logistical support needed and, therefore, reduced the delay which would have occurred from waiting on construction material to be delivered via the choked and overtaxed logistical systems. In Italy, a soft limestone called tufa, which would hardened on exposure to air, was used extensively for roads, taxiways, aircraft hardstands and parking areas (194:TAB G-14; 228:4-5). Again in Italy at Capadinechin airfield (near Naples), aviation engineers used a mixture containing 80% volcanic ash to resurface the taxiways (194:TAB G-14). Volcanic ash and coral proved to be invaluable materials in many areas of the Pacific Theater.

While many locations in the Pacific lacked sufficient gravel supplies, the coral deposits found on most islands proved to be one of the best native materials in the Pacific for airfield bases (160:TAB F-2). Coral, after being spread, sprinkled lightly with water and rolled several times produced a hard surface which resembled concrete (41:19). Unfortunately, the hardness of the coral sometimes required extensive and time consuming mining operations which included the use of dynamite at the rate of one pound per cubic yard of coral (160:8, 41:19). Coral surfaces were also susceptible to damage by propeller blast (41:19). The coral, however, proved to be a superb airfield construction material as the maintenance requirements of a well-

built coral runway were less than for those runways built of other local materials or PSP (35:5).

Other time and material saving items included the use of prefabricated facilities such as the metal Quonset huts (95:7), Nissen huts (194:TAB G-5), Butler hangars (194:TAB G-5), and the tropical shells developed from an Australian design (202:8). Research and development continued throughout WWII on various prefabricated facilities for the different theater conditions (186:1). A unique facility called the "Smessian" (25:3) or "Spainhour" (206:10) huts were developed by Lieutenant Colonel Spainhour and were constructed from readily available PBS (or hessian) and SMT (206:11). The SMT served as the arched structure to support the PBS sheathing (206:11; 194:TAB 6-2). Many other time saving items were developed, improvised and used during WWII.

The aviation engineers in North Africa constructed an earth "bellylanding" strip along the runway of Bone to reduce both airfield and aircraft damage during gear up landings (26:15). In Germany, aviation engineers turned an Autobahn (German highway) into a landing field (39:273). In the SWPA, the aviation engineers developed the "gradient" method to precisely and eventually to more quickly grade earth surfaces for airfields. This method consisted of surveyor using a transit to sight a target on the grader blade and using hand signals to tell the grader operator whether the grader blade needed adjustment (41:19). Even

during WWII, different methods of launching aircraft with catapults, winches and rocket assistance were being analyzed to reduce the need for long runways and, thereby, save valuable construction resources (90:23-24).

Construction Policy. While many time saving devices were developed during WWII, construction resources were wasted due to the lack of a firm and well understood construction policy. During WWII, there was a "Tendency . . . to approve construction on a what's desirable basis without considering what was possible to construct" (9; 193:TAB C-7-9). Because construction resources were generally more available in the rear areas, the standard and amount of construction in rear areas often exceeded requirements (146; 193:TAB C-7-9). The front area airfields were, therefore, deprived of minimum construction resources because the resources had been expended in the rear areas (9; 193:TAB C-7-9). A published policy was considered essential to insure that the area operational commanders understood the limitations, capabilities and responsibilities of the aviation engineer, and to insure that the engineers understood what type and standard of construction was expected and needed by the operational commanders (41:3). According to a Board of Officers evaluation of WWII, the lack of standardization was a "grave deficiency" (9; 193:TAB C-7-9). A firm construction policy was considered essential by aviation engineers (9; 193:TAB C-7-9). The construction policy according to the Board of Officers should:

1. Be based on operational requirements and engineering capabilities.

2. Be firm enough to promote standardization and flexible enough to allow for changes in the operational requirements.

3. Establish the channel and procedure for construction requests.

4. Establish construction priority.

5. Enforced by the Theater Air Force Commander

(9; 193:C-7-12).

The Board of Officers pointed out that significant changes in construction policy and ongoing projects should be avoided, if possible. The time needed to shift construction resources (men and materials) was very costly in terms of lost time and money (9; 193:TAB C-7-11). The Board of Officers wrote:

> Engineer troops committed to construction can be shifted less readily than can tactical elements committed to combat (9; 193:C-7-11).

While changing operational requirements inevitably necessitated changes in construction requirements, it was thought a firm and well enforced construction policy would reduce the demands for "less essential construction" (18:3). It was also noted that a well defined construction policy promoted effective planning.

Construction Practices and Trends. Before 1942, the standards for military airfields called for three intersecting runways which were generally 300 to 400 feet wide and up to 5000 feet long (41:6-7). The airfield pavements were designed to support loading up to 50% more than the

impact loading of one wheel which was assumed to support the entire aircraft weight (160:6-7). The airfield construction in the United Kingdom paralleled these peacetime standards (95:1-2; 194:1). These peacetime standards were probably the best of UK airfields as they were used throughout WWII (i.e., they were permanent), the variable and strong winds justified multiple runway and the runways for the most part supported heavy bombers and cargo aircraft.

The construction in North Africa and later in France, however, required rapid and in many cases temporary airfield construction to support the rapidly advancing allied ground forces. The AAF Engineer Command (Prov) realized that the peacetime airfield construction standards were too demanding in terms of materials, equipment, manpower and time (194:1). The XII AAF Engineer Command (Prov) was the first to simplify airfield construction by building only one runway, simple loop taxiways, and simple hardstand dispersal areas (194:1). This single runway construction policy allowed XII AF to reduce its airfield construction expenditures by about 33% (45:22).

The military operations in the Pacific greatly influenced the construction policy in the Pacific Theaters. The "island hopping" operations in the Pacific made it difficult if not impossible to determine what aircraft would be assigned to any particular airfield (41:7). The typical evaluation of aircraft, however, was light transport planes to fighter aircraft to bombers to heavy cargo aircraft

(41:2). This pattern dictated a policy which provided immediate support for the initial light aircraft (the light transport and the fighter aircraft) and then allowed the expansion needed for the heavier bombers and cargo planes (41:9). The best construction policy which evolved was to first construct an expedient runway for fighters, and then build a permanent second runway parallel to the first runway which could support the largest anticipated aircraft (41:8). A crash strip or belly strip as previously described, was also constructed to reduce aircraft and airfield damage for gear-up landings (41:8). Parallel runways were considered to offer a better chance of surviving an airfield attack, as one bomb detonated at an intersection of runways could knock out all runways which crossed at that intersection (41:8).

It was proved more effective to narrow the runway widths and increase their length (41:7). First, the length of the runway was more of an operational priority than the width (41:7). Second, heavy equipment could work a long narrow runway much faster and more efficiently than a shorter and wider runway of the same square footage (41:7). This was because longer and narrower airfields required fewer turns, stops, and backing up of heavy equipment (41:7). Another advantage of longer airfields was that they were able to support the ever increasing take-off rolls and required landing distances of the more modern aircraft with less or no runway extensions.

The very need and justification for aviation engineers was based on the realization that the grass fields which had supported the flying operations of WWI would not support the more sophisticated and heavier aircraft of WWII (7:1). This problem repeated itself and can be clearly illustrated by the Very Heavy Bomber (VHB) program established in the latter part of 1943 to support the arrival of the newly developed B-29 Superfortress in theaters of operations (14:34). Before the introduction of the B-29, runways were constructed to support aircraft such as the B-26 Marauder which had a gross weight of 35,900 pounds, the B-24 Liberator which had a gross weight of 60,000 pounds, and the B-17 which had a gross weight of 64,500 pounds (66:10; 7). Airfields supporting the new B-29 would have to be upgraded to support a gross weight ranging from 105,900 pounds (66:11) to 135,000 pounds (209:8-9). The lengths of the runways also had to be increased as the B-79 required up to to 8,500 feet for take-off and landings (160:TAB F-3; 209:8-9). The B-26, on the other hand, required only 3,500 feet (66:10-11). There was also a "growing sense" in the AAF that better living and working conditions were needed to improve the efficiency of the airmen (9; 193:TAB B-4-5). The equation of increased technology equals increased aviation engineer support requirements, as will be shown in this paper, was also a fairly constant relationship during the Korean and Vietnam Wars.

<u>Maintenance</u> <u>Policies</u>. During WWII, aviation engineer units as well as tactical units of the Air Force were involved in the maintenance of facilities and utilities (9; 193:TAB E-3-6). In the MTO, the EABs were not properly equipped or organized to efficiently maintain airfields in the rear areas (95:10). In response to this deficiency, the MTO proposed to use local civilians supervised by military personnel to accomplish airfield maintenance tasks (95:10). Although the War Department initially disapproved this proposal, utility detachments of civilian laborers were eventually authorized (95:10). These utility detachments (with 57 personnel) improved the critical maintenance situation to some degree; but, they were not as effective or efficient as hoped (95:10; 214:36). EABs were still required to perform some rear area maintenance and all maintenance in the forward areas (95:10). In the MTO rear areas maintenance was considered inadequate (95:11). In fact, the necessity to rebuild airfields at Reghaia, La Passett, Bone, and Phillipville was caused by a "lack of adequate intelligent maintenance" (95:11).

Maintenance in the ETO was to be accomplished originally by the Engineer, Air Force Service Command, using civilian laborers and some EABs from the IX Engineer Command (194:TAB B-2). This system proved ineffective, particularly, during the rapid invasion and liberation of Europe (194:TAB B-2). A Provisional Airfield Maintenance Regiment

was formed to accomplish rear area maintenance (194:TAB B-2). The use of this rear area maintenance force was very effective (194:TAB B-2). While the maintenance of operational airfields was done primarily by the Engineer Command, civilian laborers were used to accomplish routine maintenance on medium bomber fields (194:TAB B-2).

A Board of Officers, reviewing WWII experiences, reported that the responsibility for the maintenance and repair of airfields should be explicitly designated in the theater construction policy (9; 193:TAB C-8-13). The Board of Officers also noted that the construction policy should address the maintenance standards to prevent the expenditure of valuable resources on rear area frills when the front line airfields did not have even the minimum facilities required because of resource shortages (9; 193:TAB C-8-13).

Construction Intelligence and Reconnaissance. During WWII there was not enough attention and effort given to engineering intelligence (146; 193:C-1-1). In fact;

> Without realizing that there was a broad field of technical data required for aviation Engineers planning, there was a tendency to consolidate all intelligent activities under A-2, and to discourage the dissemination of engineer intelligence through technical channels (146; 193:C-1-).

Without adequate information as to the availability of local construction resources, topography and geological conditions in a specific area, and the specific needs of the operational agencies, the formulation of an engineer

plan or a construction policy was a difficult and sometimes fruitless effort (9; 193:C-1-1).

The aviation engineers were able to establish some means of internally disseminating technical information. The Air Engineer, GHQ AF, published the "Aviation Engineer Notes" which was circulated to all theaters of operation (9; 193:TAB C-1-1). This publication was well received and proved to be a good medium for circulating information on technical innovations, field improvisations, and general aviation experiences (194:TAB E-6). This publication was very similar to today's "Air Force Engineering and Services Quarterly" publication. Unfortunately, the "Aviation Engineer Notes" was discontinued in November 1945 after 41 issues, because WWII was over and this publication was considered a "non-essential" peacetime activity (55:front cover).

The Engineer Command of the MTO also produced a publication called "The Air Force Engineer". This monthly publication paralleled the "Aviation Engineer Notes", but placed more emphasis on MTO issues and problems. The Air Engineer of the China-Burma-India (CBI) Theater also published a monthly publication for distribution of technical information and Theater policies to aviation engineers in the CBI Theater (194:TAB E-4) The IX Engineer Command in the ETO did not produce any such publications.

The lack of adequate reconnaissance capability also restricted the ability of aviation engineers to gather information essential for airfield construction. Initial reconnaissance for airfield sites was generally accomplished by small aviation parties exploring and surveying potential airfield sites from the ground only. Ground reconnaissance, however, was slow and in many instances did not allow inspection of the outlying areas for items such as potential construction materials and construction hazards. Besides being slow, ground reconnaissance by aviation engineers had the potential for overlooking features such as surrounding mountains which may restrict aircraft operations (95:11). On the other hand, aerial reconnaissance, while faster and capable of inspecting the outlying areas for potential problems and resources, did not provide important details such as soil conditions and topography to facilitate a sound selection of airfield sites. It was also recognized that engineers were not qualified to look for potential restrictions to flying operations and the pilots were generally not qualified to identify potential engineering difficulties.

The answer to these problems was the use of aerial reconnaissance to locate potential sites followed by ground reconnaissance to determine soil and topographic conditions (9; 193:TAB C-3-4). The reconnaissance parties according to Major General Lynd, Commanding General, Fourth AF, should consist of the aviation engineer responsible for construction, a flying officer and a weather officer (156:5). The

IX Engineer Command of the ETO did manage to establish an aerial reconnaissance system to supplement ground reconnaissance during the invasion and liberation of Europe (146; 193:TAB C-1-1; 12:4). Reconnaissance and site selection techniques, however, were considered to be inadequate during WWII (9; 193:TAB C-3-4). Another inadequacy during WWII was the shortage of effective functioning equipment.

Equipment Problems

During WWII, the ability of the aviation engineers to accomplish their mission was dependent on the availability and the condition of their heavy equipment (194:TAB C-1). According to the Board of Officers analysis of WWII, the speed and quality of construction was limited by the type and quantity of available heavy equipment and the abilities of the aviation engineers to effectively operate and maintain the equipment. The EABs were authorized what was considered to be a "lavish amount of the best available construction equipment" (39:240). The EABs were authorized 220 pieces of heavy equipment and 146 general vehicles (97:31-30; 39:240). Even with this apparent large amount of equipment, many problems were experienced.

Probably the biggest problem was downtime of vehicles for maintenance. While a good deal of the extensive maintenance requirements resulted from operating in rugged terrain and frequent 24-hour operating days, a large percentage of maintenance requirements resulted from vehicle abuse by inadequately trained equipment operators (9;

193:TAB E-2-3; 37:2). It was felt that heavy equipment operators needed more realistic training on the operation and routine maintenance to get the best use of the equipment (194:TAB E-2, 51:27).

Another maintenance problem was the lack of or lack of control of equipment maintenance units. During WWII, the equipment maintenance units "were largely assigned to other than the Air Force." The lack of equipment maintenance units in the MTO severely handicapped airfield construction (45:15). Request from the MTO for additional equipment maintenance personnel was never approved (45:15). In the Pacific Theater, an engineer maintenance company on Luzon was responsible for supporting 22 units of various sizes (160:6). The most effective ratio of engineer maintenance companies to EABs was one to six (194:TAB B-8; 160:6). An analysis of WWII experiences indicated that it was imperative that aviation engineers have an organic vehicle maintenance (9; 193:TAB D-5-4-5).

Another major equipment problem was the lack of adequate spare parts. The MTO as did the other theaters, suffered spare part shortages (45:15, 160:3).

> . . . This lack of spare parts during the first year caused damage to equipment from which it never recovered. For example, lack of fuel filter elements for diesel equipment resulted later in wornout fuel injectors and a whole train of defects (45:15).

This quote shows that failure to provide maintain vehicles properly results in reduced effectiveness and continuing long-range problems.

One of the most frustrating problems which occurred during WWII was the inability to have the heavy equipment arrive at the same point of debarkation, and at the same time as the aviation engineer units did. At the beginning of WWII, transportation for men and especially for equipment and supplies was the most limiting factor (39:244). In the February 1944 issue of "Aviation Engineer Notes," Major Lawrence M. Cook wrote in his article "Training Recommendations."

> Organizations and individuals should be made to realize that for days or even months, after their arrival at an overseas destination they may have little if any of their own equipment with which to work, and will, therefore, have to resort to all sorts of methods to accomplish assigned tasks (51:28).

This statement certainly seemed to be true for the African and Sicilian campaigns where no unit was able to obtain all of their equipment at one time (15:TAB C-1). Engineer aviation units in the MTO operation had to wait up to 90 days before they received all of their equipment (15:TAB C-1). Those units that received all of their equipment were fortunate as equipment without accompanying operators was almost always lost (15:TAC C-1). Theft of vehicles and vehicle parts became so severe in the MTO that two operators

were assigned to each vehicle, steering wheels were chained and locked, pilferable items were removed, and tool boxes were welded shut (15:TAB C-1).

The experiences in the ETO were very much the same as those in the MTO. Equipment sent directly to the theaters without its operators often was lost to its units (194:TAB E-1). Crowded dock facilities in the UK were a primary reason aviation engineers experienced long delays in receiving their equipment (39:247). Inadequate port facilities as will be shown, covered similar problems for aviation engineers in the Korean and Vietnam Wars.

When the equipment did arrive the aviation engineers experienced problems in unloading the equipment because of improperly loading, packaging, and/or marking of the equipment (39:249; 160:TAB B-3). In many cases the improper loading resulted in damaged equipment. For example, one unit received two shovels with controls frozen by rust, a crane with its controls also frozen by rust and two graders with rusted-in-motors (160:TAB B-3).

Equipment problems were also experienced with the generators. The standard 3KVA generators were considered unsuitable for continuous operations (194:TAB C-2). These generators were also too small to support the typical 15KW loads of the EABs (194:TAB C-14). Diesel powered 5KW and 10KW generators were determined to be the best units to provide continuous power for the various size aviation units (194:TAB C-2, TAB C-14), however, these were not available.

There were numerous other equipment problems experienced during WWII (160:TAB B-11). The primary problems, however, were inexperienced operators, unskilled maintenance personnel, rugged working conditions, and the lack of spare parts needed for equipment maintenance.

Logistical Problems

As mentioned earlier, the equipment problems were in many cases related to logistical problems (i.e., the lack of spare parts and the lack of adequate transport). Supply for the aviation engineers during WWII was considered "inadequate and unorganized" (45:TAB G-1). There were many reasons why aviation engineers experienced supply and transportation problems.

Aviation engineers argued that their subordinate positions (i.e., serving under the Air Force Service Command or under Army control) excluded them from directly participating in the tactical and logistical planning (9; 193:TAB B-1-1). The engineering equipment and supplies because of their size, weight, and importance to the construction of airfields, required careful considerations when planning tactical operations involving aircraft (95:11). Aviation engineers, therefore, stressed that they should be allowed to participate in the initial tactical planning so that the tactical commander would understand the magnitude of engineering effort that would be needed to support the proposed tactical plan (207:TAB B-1; 95:11). The aviation engineers

would also understand the requirements of the tactical commander and the other supporting organizations (95:11). General Lynd, Commanding General, Fourth Air Force, recognized the importance of including aviation engineers in the initial planning of tactical operations when he wrote:

> This is a war of movement - extremely so in the case of Air Forces. So first we must have some excellent staff work in which the Air Force engineer plays a large part. (156:4)

Another source of supply problems was the constant shifting of the functional control of the aviation units from one organization to another. An aviation unit would request supplies through the supply agency of one organization and, before the supplies were obtained the aviation engineer unit would be re-assigned to another organization. The original request was either canceled or the supplies were never delivered; forcing the aviation engineer unit to re-order the needed supplies. If the unit was re-assigned again, the vicious cycle would continue. Many aviation engineering units in the Pacific Theater experienced this situation (8:3).

Similar conditions occurred in the MTO when the Base Section Supply of Service took over supply responsibilities from the North African Task Force after the invasion of Africa (45:14). When the Base SOS assumed supply responsibilities, previous requisitions submitted to the Task Force by Air Force units were canceled. The Air Force units

including aviation engineering units were forced to resubmit requisitions to the Base SOS. Action was needed to correct these problems.

The establishment of the Engineering Commands in the MTO and ETO insured that aviation engineers had a timely input into the tactical and logistical planning (194:TAB B-3). For example, during the planning of Operation OVERLOAD (the invasion of Normandy), the Chief Engineer, IX Engineer Command was assigned to the IX Air Force Planning Group to participate in the planning of operation OVERLOAD (194:TAB B-3). The Engineering Commands were also able to monitor the supply status of aviation engineer field units and in many cases the Command Engineer was able to use his influence as a member of the Command Staff to procure essential supplies.

The distribution and control of supplies within the Theaters continued to cause problems for the aviation engineers (207:Appendix G-4). The Army's SOS controlled the distribution of common construction items such as lumber, asphalt, and corrugated sheeting (207:Appendix G-4). Problems occurred within this system as the SOS required these construction supplies to accomplish their own construction tasks (207:Appendix G-4). The SOS distributed construction supplies based on their priority system and generally without regard as to what agency actually had initially requested the supplies (207:Appendix G-4).

Although the Air Force Service Command requisitioned and controlled special construction items peculiar to the Air Force, such as PSP and portable hangars, problems still occurred. Even when these materials were successfully ordered and received by the Theaters, there was generally not enough rail and vessel cargo space authorized for the Air Force to transport the heavy and bulky supplies to the aviation engineer units in the field (207:Appendix G-4). The aviation engineer units did not have enough organic transport to haul supplies from depots greater than 20 miles (207:Appendix G-4). Nor did the engineering units organized or equipped to perform extensive construction and to haul supplies at the same time (207:Appendix G-4).

The transportation of equipment, supplies, and men was the most limiting factor during the early phases of WWII (39:244; 219; 238:4-5). The transport of equipment and supplies was always considered inadequate in the Pacific Theaters (particularly in the island hopping operations). The tremendous weight and bulk of engineering equipment and supplies; the high shipping priority given to munitions, fuel, and aircraft parts; and inadequate or non-existent port facilities combined to complicate the aviation supply problem during WWII.

Transportation within the theaters of operation (particularly the remote Pacific Areas) was made difficult by the usually inadequate railway and road systems in the theaters. An all to common problem was, again, the under

estimation of the tremendous space and weight allowance needed for engineering equipment and supplies (207:Appendix G-3). Transportation allowances were also needed for non-construction supplies such as clothes and rations.

Another problem encountered with the Base SOS supply units was the lack of capability to redirect available items at one base to another base which needed and lacked the supply items (45:14). This problem was eliminated by the establishment of a strong SOS Headquarters which directed resources as needed to meet construction requirements (45:14). The Air Force was able to advise a single SOS Headquarters versus many independent Base SOS units of supply deficiencies. The SOS would in turn survey the Base SOS units for the needed supplies. If the supplies were available, the SOS would direct the transfer of required supplies to the requesting aviation engineering units (45:14).

The MTO supply situation for aviation engineers was also improved when the SOS Headquarters established specific stock levels for aviation engineer construction supplies (45:15). The assignment of Engineer Depot personnel to the SOS insured that supplies were properly identified, unloaded, and stored for eventual distribution to aviation engineer units (45:15). The aviation engineers in the SWPA were not so fortunate as they were not initially provided with a sufficient number of trained Depot Companies (160:TAB

B-1). This situation was probably the result of the emphasis to increase construction capability at the neglect of supporting aviation engineer units (160:3-4, TAB B-1). The lack of Engineer Depot Companies in the Pacific Theaters resulted in the loss and damage of aviation engineer supplies (160:TAB B-1). Despite these improvements the logistical support for aviation engineers was considered inadequate.

While the shortage of equipment spare parts was considered the most critical supply problem, there were shortages in other ares which adversely affected aviation construction capability. Oils and greases needed to keep equipment operating were also in short supply (160:TAB B-7). As previously mentioned, the aviation engineer had a difficult time procuring common construction materials such as lumber because their distribution was controlled by the SOS which also needed these supplies.

The aviation engineers were also in competition with other military organizations for such supplies as clothes and food. While almost all military forces considered their clothes and rations to be inadequate, the aviation engineers argued they needed special consideration. Heavy construction, they argued, demanded more clothing and rations.

The aviation engineers contended they needed additional clothing because they were often required to work in harsh environments (i.e., jungle, extreme climates, etc.) The aviation engineers stressed that rigorous construction

was by its nature hard on clothing. For example, the clothes of the aviation engineers in Africa during the rainy seasons of 1942-1943 were described as patches of rags and holes held together by bits of thread (214:5). The lack of protective clothing such as gloves and boots led to many injuries (214:5).

The aviation engineers also stressed that personnel involved in 24-hour construction operations needed extra rations to maintain their health and effectiveness (9; 193:TAB E-1). Unfortunately, normal supply procedures frequently did not work and unorthodox procedures were invoked.

In many cases, the aviation engineer supply sergeants "shifted in ways better known to himself, ways not strictly GI " to obtain supply items for his unit. For instance, the Army supply personnel felt that all AAF units "had it better" than they did and were, therefore, reluctant, to relinquish supplies to aviation engineers (39:271). The aviation engineers took the approach; "if you can't beat them, join them;" and removed all AAF markings from their uniforms and vehicles before approaching Army supply sergeants for assistance (39:271). The barter and exchange system were used to trade services for supplies and supplies for services. When the official supply system and the barter and exchange system failed, the system of permanent

midnight requisition was implemented. The aviation engineers also became, as other units did, masters of improvision and cannibalization to keep things going (39:285).

To eliminate these problems, the Board of Officers in their analysis of WWII experiences recommended that common construction items should be placed in central depots where the three services (Army, Navy and Air Force) would withdraw bulk issues based on a predetermined and strictly enforced credit system (9; 193:TAB D-4-4). The Air Service Command would then be responsible for controlling the distribution of common Air Force supplies. Unique aviation engineer supplies should be distributed by the Air Service Command as directed by the Engineer Command (9; 193:TAB D-4-4). The Board also recommended that careful consideration and planning be given to the transportation needed to distribute the supplies (9; 193:TAB D-4-4).

Personnel Problems

Induction and Assignment Problems. The innovative supply procurement techniques described above indicate the importance of having highly motivated and intelligent personnel to resolve and accomplish difficult tasks. For the most part, the aviation engineers operated "on a high plane of efficiency" (160:TAB G-3). There were several personnel problems which were experienced during WWII.

Personnel problems began during the induction and selection of aviation engineer personnel. The Army

induction and assignment procedures did not adequately consider the skills and experiences of the individual civilian inductee (9; 193:TAB E-2-2). As a result, an experienced bulldozer operator or a pavements expert frequently was assigned to combat units or other units which would not utilize the special skill (9; 193:TAB E-2-2). Consequently, unskilled and ignorant personnel were often assigned to the aviation engineers. The Board of Officers in their analysis of WWII wrote:

> This single grievous error seriously handicapped our Army Air Forces and Army in the early stages of the war when they were forced to employ engineer organizations greatly inferior in technical skill to those which could readily be formed from the construction industry (and were so formed by the Navy) (9; 193:TAB B-2-5-6).

The Navy used a program of industrial induction (9; 193:4) to obtain civilian personnel with expertise in construction and to assign them to tasks in which they were specially skilled (9; 193:TAB E-2-2). Specific job descriptions with equally specific designators for the job descriptions were established by the Navy to prevent misassignment (9; 193:TAB E-2-2). Equally important was the creation of military positions which would coincide with civilian positions in terms of rank and pay (9; 193:TAB E-2-2). The designators for aviation engineer job specialities were not specific enough to insure the most efficient use of personnel (194:TAB D-1, 9; 193:TAB E-2-2).

Training Problems. Aviation training requirements were greater than necessary because, instead of receiving civilian inductees with construction expertise, they received, in many cases, personnel with no construction experience or aptitude. The immediate demand for aviation engineers, unfortunately, resulted in many aviation engineers being sent to overseas theaters with little or no training (194:TAB E-1). Most of the initial units were sent to the UK within three or four months of activation even though they had received little if any training (96:2). These units were suppose to receive their technical training in the UK (96:2). This lack of trained aviation engineers was prevalent throughout all the Theaters of Operations (194:TAB E-6). The lack of stateside training meant that extensive on-the-job training was required (9; 193:TAB E-2-3).

On-the-job training, while essential, had many drawbacks. First, productivity was reduced as experienced and more productive personnel were taken off work tasks to train inexperienced personnel. Second, on-the-job training was, frequently, downgraded to learn-by-trial-and-error in order to meet critical construction deadlines (160:6). When supervised training was abandoned, inexperienced personnel caused excessive equipment damage and costly delays.

The primary training deficiency was in the training of heavy equipment operators and maintenance personnel (194:TAB

E-5; 7; 8; 150; 241:1). Less than one-tenth of the replacements received by the 808 EAB in the South Pacific were capable of operating heavy equipment (236:1).

While too little emphasis was given to equipment operation and maintenance training, the aviation engineers felt that too much emphasis was placed on combat training (194:TAB E-7-8; 8:1). Aviation engineers of the MTO and ETO said the training of new aviation engineers should emphasize:

a. Operations and care of equipment.

b. Planning for and complete operation of task jobs.

c. Around the clock operation.

d. Standard technical practices including preparation and drainage of subgrades, standard surfaces, tested expedients.

e. Operational facilities and structures.

f. Combat and semi-combat functions.

(194:TAB E-8)

Training on the erection of prefabricated facilities (51:27), in the reconnaissance of airfield sites (9; 193:TAB E-2-3; 51:27), and in bomb and mine removal (194:TAB E-5; 160:TAB D-3) was also stressed by the aviation engineers of WWII. It was also recommended that the aviation engineers be instructed on the customs of foreign cultures as they differed substantially from U.S. customs (51:28).

Training aviation engineers at the beginning of WWII, as mentioned earlier, was very difficult because of the

immediate demand for aviation engineers. The aviation engineers knew they must maintain a high state of readiness, as the initial deploying unit could not have time to train. They recognized, however, that finding peacetime work assignments which would help them maintain their readiness would be difficult, if not impossible (216:4). The aviation engineer, therefore, recommended that the establishment of one or more aviation engineer training centers would insure readiness and provide a capability to train additional engineers, if needed (9; 193:TAB E-2-4).

Manning and Replacement Problems. The stateside training deficiencies were unfortunately, reflected in the replacements to aviation engineer units. Although replacements for the IX Engineer Command were for the most part satisfactory, by February 1945, the lack of adequate replacements became the most critical problem (194:TAB D-2). The Engineer Command of the MTO also experienced serious replacement problems, as only above 10% of the replacements had any technical training which was useful to the aviation engineers (194:TAB D-2). As mentioned earlier, the Pacific Theaters also experienced replacement problems. For example, only about one-tenth of the replacements arriving to the 808th EAB in the South Pacific were able to operate heavy equipment (236:1). After arriving to the MTO, the aviation engineers received no enlisted replacements for approximately 16 months (45:18).

At one point during this period, the MTO aviation engineers were approximately 900 enlisted men short of their authorized strength (90% manned) (45:18). The replacements which began arriving in March 1944 "were frequently non-engineers" (45:18).

Many units in the Pacific Theaters complained that the replacements were unfit. The 801st aviation engineers claimed they had received 30 psychopaths out of 300 replacements (160:TAC C-3). Another company stated that 14 out of their 42 replacements had previous criminal convictions (160:TAB C-3). The units also appeared to have a difficult time getting rid of physically unfit personnel (160:TAB C-3). In fact, the aviation engineers were required to provide able bodied and experienced personnel from their own rank and file to fill vacant infantry combat positions. In return, the aviation engineers received men who were unfit for combat (194:TAB D-3). During the latter years of WWII, an average of 45 to 50 men were taken from the EABs in the MTO and ETO to serve in combat (194:TAB D-3). Naturally, this reduced the effective manning of the aviation engineer units.

During 1945, the manning of EAB in the MTO and ETO averaged less than 700 men (194:TAB D-3). The aviation engineers complained and argued that they had already been undermanned and the practice of withdrawing skilled personnel reduced their construction capability and the morale of their forces (9; 193:TAB E-4-1).

One of the major personnel problems was the lack of enough personnel for the frequent 24-hour per day construction operations (160:TAB A-4; 207:Appendix H-3). The aviation engineers complained that their Table of Organization (T/O) did not authorize enough personnel with the right skills to provide for 24-hours per day construction (160:TAB A-4). The primary shortage was in the number of authorized equipment operators. The aviation engineers pointed to the Navy Construction Battalion which had 25% more personnel than the EABs to operate 15% less equipment (160:TAB G-2). The T/O which was based on the concept of one EAB per two Air Force Groups was considered to be adequate only for providing airbases with minimum operational facilities (9; 193:TAB E-4-21). The aviation engineers contended that the T/O would probably need to be upgraded to support the increasing requirements created by rapidly advancing technology and trends for better living/working conditions (9; 193:TAB E-4-71). An increase in the T/O to provide enough men with the right skills to perform 24-hour per day construction was also recommended (160:10).

Morale. Despite the manning problems and the rigors of around-the-clock construction, aviation engineers throughout WWII maintained a relatively high state of morale. The aviation engineers recognized that morale had a dominating effect upon their efficiency (160:6). The major

factors affecting the aviation engineer morale in the Pacific theaters and probably all aviation engineers were (in order of importance):

a. Kind of work
b. Redeployment or return to the U.S.
c. Recognition of effort
d. Operational control
e. Double standard of living
f. Morale equipment (ice cream machines and movie, projectors, etc.)
g. Leaves, rest, working hours
h. Blocks to advancement
i. Officer problems
j. Integration

(160:6)

One of "the greatest prerequisites to the development of the competency and morale of individual engineers . . . is plenty of high grade professional work" (216:4). This was the case in the Pacific Theaters as the aviation engineers preferred to do meaningful engineering construction type work (160:TAB E-1). In fact, the medical officers stated that the number of aviation engineers reporting to sick-call would "reduce in direct proportion with the amount of work and the interest taken in that work" (160:TAB B E-1).

It was also noted that the stimulus of new construction operation could temporarily rejuvenate personnel suffering from "combat fatigue" or nervous breakdown (160:7). The "combat fatigue" suffered by aviation engineers resulted from working for 10 to 12 hours per day,

seven days a week for three to four years (160:7). Varying the job assignments helped to reduce sick call rosters (160:7).

Aviation engineers who had been working in the overseas theaters for three to four years were all asking the same question; "when do we go home" (160:TAB E-1).

As the European operations were phasing down in 1944, the morale of the aviation engineers declined as redeployment to the Pacific Theaters was being considered (194:TAB E-1). The aviation engineers who had been working in the remote Pacific Theater jungles and islands were also wondering when they could go home (160:TAB G-3). The aviation engineers were skeptical (especially those who had been overseas for three to four years) of a rotation policy which they felt was both confusing and inadequate (160:19, TAB G-3). The aviation engineers were also frustrated to see the Seabee units returned to the U.S. every 18 months for rehabilitation and retraining (160:TAB E-2).

A better rotation was not the only advantage the Navy construction units enjoyed over the aviation engineers. A major morale problem for the aviation engineers was to see the Navy had better living conditions, better rations, better PX supplies and other items which the aviation engineers did not have such as refrigeration (160:7). The Navy had an obvious advantage since they had the ships which could bring these items directly from the States (160:TAB E-3). While the AAF and its attached units were able to use

air transport to maintain better living standards than Army units, the Navy's better standard of living was a constant morale problem for the aviation engineers (160:TAB E-3).

The morale of the aviation engineers also declined when they were required to provide other units with creature comforts, which they did not have (160:TAB E-3). This resentment was amplified when the aviation engineers had to work overtime to build nice-to-have facilities for organizations which only worked an eight-hour day (160:TAB E-5).

As indicated by the list of morale factors, the recognition or lack of recognition affected morale more than the double living standard factor. Most aviation engineers agreed that "prompt and fitting" acknowledgment of a job well done was one of the most "stimulating influences on the morale of a unit" (160:TAB E-2). Tight security restrictions imposed by the Army on construction accomplishments sometimes precluded proper recognition of aviation engineers (160:TAB E-2). Frequent transfer from the control of one organization to the control of another also seriously affected morale.

The 808th EAB was reassigned seven times in less than two years (241:3). Many other units in the Pacific Theaters were never assigned to any one agency for more than two months (160:TAB G-1). As mentioned earlier, the constant reassignment disrupted the flow of supplies to the aviation engineer (160:TAB E-3). The processing of administrative items such as leave, promotions, rotations and letters of

appreciation was also disrupted by constant reassignment. The aviation engineers had no command agency to turn to for assistance and began to feel that they had been foresaken. The creation of the ETO and MTO Engineer Commands provided one centralized control which could insure proper resupply of the EABs and reduce administrative deficiencies and give the EABs a feeling that someone was looking after them (45:8).

The final morale factor listed above was integration. Many aviation engineer officers were concerned that being assigned to a subordinate staff in the Air Force would result in the "dissipation and enervation" of the aviation engineer forces (216:2). They felt they could better serve the Air Force "as the Engineer member of a team than as a member of the family" (160:TAB E-6). The aviation engineers resented non-engineering personnel being assigned to and placed in command of aviation engineer units. On the other hand, the non-engineer Air Corps officers, who were often assigned against their wills to aviation engineer units, resented being assigned to the aviation engineers (160:5-8, TAB C-3). This mutual resentment adversely affected morale. Often complicating morale problems were the medical problems experienced by aviation engineers.

Medical Problems. Poor living conditions, long hours of rigorous work, harsh environments and climates, the lack of adequate food and water, and the diseases, such as

malaria and dysentery posed many medical problems for aviation engineers in all theaters of operation.

Long hours on heavy equipment resulted in spinal, back, and kidney problems for operators (194:3). The shortage of food one EAB in the SWPA resulted in an average weight loss of 30 pounds per man during operations at Saidor (39:283). Dysentery, inadequate food, and foul water would sometimes combine to produce even greater weight loss. Many felt that the provided rations were not adequate to sustain men doing heavy construction (36:2). As a result, one of the recommendations of a Board of Officers which analyzed WWII experiences, was that extra rations should be provided to aviation engineers involved in 24-hour operations (9; 193:TAB E-1).

Aviation engineers also suffered from other common problems such as lack of medical supplies. The EABs were fortunate, however, to have a small organic medical company to handle minor medical problems and medical emergencies.

Aviation engineers recognized the importance of a sufficient construction force which was well trained, organized, motivated and healthy. They strived throughout WWII and following WWII to obtain this force. One such effort was an analysis of WWII aviation engineering experiences performed by a group of officers who had served as and with aviation engineers during WWII.

Summary

During the preparation and build-up of WWII, the Chief of the Army Air Forces recognized the need for specially trained engineers to construct, repair, and defend forward air bases. After successful negotiation with the Chief of Engineers, the AAF were authorized aviation engineer forces to construct, maintain, and repair forward airfields. On 4 June 1940, the first aviation construction unit was formed with the creation of the 21st Engineer (Aviation) Regiment. In February of 1945, the aviation engineers reached their maximum strength of 117,851 personnel. These aviation engineers were to be assigned to the Army Air Forces and be employed primarily on airfield related projects.

The aviation engineers were, however, controlled by the Army's Supply of Services and other agencies as deemed appropriate by the theater commanders. The Army Air Forces top leadership and aviation engineers complained of the control of aviation engineers by the Army and Navy. The Army Air Forces argued that it needed its own organic construction force to insure that it could rapidly build airfields to the standard needed to support the projection of airpower. While aviation engineers agreed with the Army Air Forces, they also wanted to establish Engineer Commands within the theater of operations.

The aviation engineers argued that unless they were represented on the General Staff of the theater commands

the, aviation engineer construction capability would be adversely affected. The aviation engineers were successful in establishing Engineer Commands in the MTO and the ETO. The 12th Air Force Engineer Command Provisional, of the MTO established on 26 October 1945, was the first such Engineer Command. The proven responsiveness and success of this Engineer Command in North Africa influenced the establishment of the IX Engineer Command for the ETO. Although the Engineer Command of the MTO and ETO were very successful, no such command was established in the Pacific Theater.

Aviation engineers contended that problems experienced during WWII were the result to some degree of the control of aviation engineers by non-Air Force organizations or subordinate positions on the General Staff of the Theater Commands.

Many of the construction problems, however, resulted from the harsh climates and environments found in the Theaters of Operations. The combination of the heavy rainfall; the low laying, hard to drain topography; and the poor drainage qualities of the soil found in many theaters adversely affected airfield construction. Most failures of airfield surfaces were due to the lack of consideration and effort given to providing adequate airfield drainage.

The lack of a well established industrial complex in the remote areas and areas devastated by war also greatly affected construction capability. Inadequate transportation

systems and utility systems, lack of local equipment and supplies, and the lack of local labor forces complicated airfield construction. The premise that there would always be enough local labor to supplement small military construction forces was proven to be false during WWII, particularly, in remote Pacific areas.

The initial absence of an established construction policy in most theaters proved to be another major problem for aviation engineers. The lack of a construction policy which specified airfield construction standards resulted in tendencies for rear area bases to use valuable construction resources for elaborate construction. The forward airfields were, therefore, deprived of resources needed to construct the minimum essential facilities. Planning aviation support for tactical operations without a construction policy to facilitate estimates for needed engineering resources was difficult and inaccurate.

The construction policies had to be flexible to allow for mission changes and for airfield expansions/upgrades needed to support the introduction of modern aircraft such as the B-28. The aviation engineer's existence had been based on the need to support the modern WWII aircraft which were more complex, heavier, and faster than WWI aircraft. The introduction of the B-29 during WWII reminded aviation engineers that future aircraft would require more and more engineering support.

A significant change in airfield construction standards took place in the MTO. Aviation engineers in the MTO realized that the peace time standard used to construct American airfields in England were far too elaborate. In order to rapidly construct airfields the, MTO engineers simplified airfield standards from three intersecting runways and extensive taxiways and dispersed areas to a single runway with simple parallel taxiways and minimal dispersal areas. The aviation engineers of the Pacific Theater adopted a similar policy of simplified airfield construction. The "island hopping" tactics used in the Pacific Theater, however, necessitated the use of parallel runways. The first runway was constructed using expedient methods and standards to allow immediate use by small cargo and fighter aircraft. The second runway was then constructed using standards for permanent airfields to support the heavier bomber and transport aircraft. The original runway would then usually be upgraded.

Regardless of the specified construction standards, the speed and quality of airfield construction was usually determined by the availability of heavy equipment. Although the aviation engineers were authorized a substantial amount of heavy equipment (220 pieces) and vehicles (146), inexperienced operators and maintenance personnel, rugged 24-hours per day operations, and the lack of spare parts resulted in many precious hours of equipment downtime. The

lack of available and fully operational equipment was a constant problem for aviation engineers. The aviation engineers also experienced construction problems when their equipment was delayed, damaged, or lost during shipment from the U.S. or previous assignment locations.

The logistical support for aviation engineers was considered inadequate and "unorganized." The inadequate supply of equipment spare parts resulted in permanent vehicle damage and costly construction delays. The lack of construction supplies also handicapped the aviation engineers.

Aviation engineers claimed there were two basic reasons they experienced severe logistical problems. First, the Army's Supply of Services controlled all construction items which were common to the Army and the Army Air Forces. Second, the exclusion of aviation engineers from initial tactical and logistical planning resulted in underestimation of the engineering effort needed to support an operation. The planners also often neglected the massive bulk and weight of engineering equipment.

Distribution of supplies were also disrupted by the constant shifting of an aviation engineer unit from one command to another. Aviation engineers argued that the Creation of Engineer Commands insured that requirements were included in essential logistical and tactical planning. The Air Engineers of an Engineer Command were also able to use their influence on members of the General Staff to obtain

essential supplies. When all official supply systems failed, the aviation engineers used "creative and innovative" methods to obtain supplies. Although aviation engineer personnel in many cases were innovative and highly effective, there were many personnel problems.

Personnel problems resulted from the initial induction, selection and training of aviation engineers. In many cases, individuals with no experience or aptitude were selected upon induction as aviation engineers. Training was sporadic and in many cases aviation engineers were sent to theaters of operations without any training.

The inexperienced and untrained personnel were not well received by aviation engineer units which were generally undermanned and overworked. The aviation units were often required to supply as many as 50 able and experienced aviation engineer troops as combat replacements. In return, engineer units received more untrained personnel and personnel physically or mentally unfit for combat duties.

Despite the many hardships, the overall morale of aviation engineer units during WWII was considered very good. As discussed there were many factors which affected morale.

The aviation engineer realized many initiatives would be needed to eliminate the previously mentioned problems. Aviation engineers also anticipated that the Air Forces would soon be separated from the Army and established as an independent service. A now independent Air Force would need an effective construction force.

The Secretary of War agreed and on 3 July 1946 directed that a Board of Officers be established (148:1). The Board of Officers was to analyze WWII experiences and determine the most effective "organization, equipment, employment, and control of Aviation Engineers" (140:1).

The Board of Officers was chaired by Brigadier General George J. Nold (148:1). The remaining eight members were all Civil Engineering Officers. This report was considered "unique" because:

> ". . . the Board members were neither the leading Air Engineers nor their Deputies in each of the several Theaters of Operations during World War II and hence the procedures that are recommended are based on the world wide integrated experience of responsible individuals who have served in the field" (9; 193:1).

Their report was "approved in principle by the Commanding General AAF on 8 January 1946" (6:Forward). The report was received by the Air University at Maxwell Field, Alabama in April of 1947 (72:2). Air University agreed with the recommendations made by the Board of Officers, and considered the report an ". . . excellent . . ." and ". . . valuable guide for future Air Forces" (72:2).

Board of Officers on Aviation Engineers was an excellent review of the problems experienced by aviation engineers during WWII. The recommendation made in this report address, in the authors' opinions, the solutions to major problems experienced by aviation engineers during WWII. The recommendations are presented as both a summary of WWII problems and as an introduction to the needs of

aviation engineers following WWII and prior to the Korean War. The following recommendations were taken directly from the Board of Officers report on Aviation Engineers (9; 193:3-4).

a. That Engineer Special Staffs be included in Theater Air Forces and subordinate Air Forces commands down to and including the wing and corresponding elements of Air Service Commands, and that the Air Forces Engineer be responsible for technical supervision of all aviation engineer operations in the Theater.

b. That the engineer construction forces supporting Theater Air Forces be organized into an Aviation Engineer Command responsible directly to the Theater Air Forces commander; and that similar engineer commands of suitable size be organized in each Air Task Force or other special air command operating on a detached or independent mission.

c. That the Aviation Engineer Command be composed of a balanced force of brigades, groups, battalions and supporting supply and service units.

d. That the senior aviation engineer officer with the Theater Air Forces be assigned as Theater Air Forces Engineer and as commander of the Engineer Command.

e. That the staff engineer assigned to any subordinate Theater air command, command such aviation engineer units of that command as are not assigned to subordinate commands.

f. That the Aviation Engineer Command be charged with all responsibility for construction for the Theater Air Forces, including site planning, design, construction, petroleum distribution lines and maintenance of its engineer equipment.

g. That the peace time Aviation Engineer establishment be so organized as to permit expansion readily to a war time basis without major reorganization.

h. That the assignment and utilization of Aviation Engineer Topographic Units be made a matter of further study by the Air Force to determine necessary modifications of policy.

i. That a clear and firm construction policy be established by the Theater Air Commander to include criteria and standards for construction, maintenance and repair, priorities for construction, and general procedure for satisfying construction requests.

j. That the Air Forces Engineer be informed of tactical plans sufficiently early to permit the timely formulation of an overall construction program.

k. That a definite program be prescribed by the Theater Air Forces Engineer for the collection, screening and dissemination of information on new construction methods and techniques, and modifications of engineer equipment developed within the Theater Air Forces.

l. That standardization of engineer equipment be carried to the point of providing only one model in the Air Forces, and if possible within Air, Ground, and Naval Forces; that commercial types be used exclusively except when such types cannot meet special military requirements.

m. That the immediate Research and Development program specifically provide for material suitable for use in Polar operations and for transport by air.

n. That the Theater Air Service Command be responsible for supply of all engineer items allocated to the Theater Air Forces.

o. That "Industrial Induction" or recruitment of Aviation Engineer personnel and units be initiated and utilized as far as possible; that provision be made for waivers of age and physical standards that will not affect engineer operating efficiency.

p. That Negro personnel be utilized in the Aviation Engineers only in such proportion as existing skills permit their assimilation in complete units.

q. That one or more Aviation Engineer Training Centers be established in the Zone of the Interior with the mission of providing completely trained individuals and units of all types, thus making training an Aviation Engineer responsibility from the completion of the screening process.

r. That the maximum possible level of experience in heavy construction be assured Aviation Engineer units by their employment in time of peace on major construction project, and that training of officers in time of peace be supplemented by assignment to duty in conjunction with major civil works.

s. That adequate allowances be made in training of colored Aviation Engineer units for extra training time, for additional instructors, and for additional officers.

t. That Aviation Engineer construction units be manned and equipped for 24-hour operation.

u. That T/O&Es for Aviation Engineer units be developed in accordance with the recommendations of Tab E-3.

v. That Aviation Engineers consist primarily of two type units for heavy earth-moving and structural work, respectively, both lightly armed, and the former generally trained for participation in amphibious, airborne, and mobile ground operations and more heavily armed in actual employment in such operations.

w. That Air Depots be assigned such engineer depot, parts supply and equipment maintenance units as are required for engineer operations at the Air Depots.

x. That Aviation Engineer troop units be provided on the troop basis as indicated in Tab E-5.

IV. Korean War Era (1946-1953)

The importance of airpower had already been demonstrated during WWII. The 80th Congress recognized this importance and on 26 July 1947 enacted Public Law 253 (National Security Act 1947) which established the Department of the Air Force. The Air Force thus became one of three co-equal executive departments under the newly formed National Military Establishment.

The National Security Act of 1947 required the transfer of the Army Air Forces, the Air Corps of the Army, and the General Headquarters of the Air Force to the United States Air Force (USAF) (166:500-503). All military personnel previously assigned to the Army Air Force or the Air Corps of the Army were to be transferred to the USAF (166:500-503). Military personnel assigned to any component of the United States Army and under the "authority of command" of the Commanding General of the Army Air Forces were to remain under the "authority command" of the Chief of Staff, USAF (166:500-503). The National Security Act also addressed the transfer of installation and property from the Army Air Forces to the United States Air Force.

> Except as otherwise directed by the Secretary of the Air Force, all property, records, installations, agencies, activities, projects, and civilian personnel under the jurisdiction, control, authority, or command of the Commanding General, Army Air Forces, shall be continued to the same extent under the jurisdiction, control, authority, or command, respectively, of the Chief of Staff, United States Air Force, in the Department of the Air Force.

> For a period of two years from the date of enactment of this Act, personnel (both military and civilian), property, records, installations, agencies, activities, and projects may be transferred between the Department of the Army and the Department of the Air Force by direction of the Secretary of Defense.

It was obvious that the Air Force would become responsible for the maintenance of airfield installations. Actually, the Army Air Force had been given the maintenance responsibilities with the publication of War Department Circular 388 (50:3). The technical supervision of maintenance and the maintenance funds were still controlled by the Chief of Engineers from 1944 to 1946 (50:3). In 1946, the technical supervision of airfield maintenance was transferred to the Army Air Forces. As result of this transfer of maintenance supervision, the title of the person responsible for maintenance of an airfield was changed from the Post Engineer to the Air Installation Officer (AIO) (50:3). The enactment of the National Security Act in 1947 permanently and officially transferred maintenance and real property functions to the USAF (166:500-503; 50:3). The primary concern of the aviation engineer of WWII, however, was an organic capability to construct and maintain forward airfields.

The National Security Act, however, did not provide the Air Force with its own construction force (166:500-503). While stating the Air Force would be responsible for preparing its units for war, the National Security Act as shown below provided an exception which blocked the formation of an Air Force construction capability:

> In general the United States Air Force shall include aviation forces both combat and service not otherwise assigned. It shall be organized, trained, and equipped primarily for prompt and sustained offensive and defensive air operations. The Air Force shall be responsible for the preparation of the air forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Air Force to meet the needs of war . . . (166:500-503)

The National Security Act basically required the Air Force to work with the Army to establish a joint agreement as to who had what responsibilities of constructing and maintaining airfields in the preparation for and during war.

On 15 September 1947, the Army-Air Force Agreement as to Initial Implementation of the National Security Act of 1947 was published. This joint Army-Air Force agreement basically stated that the Army would be responsible for all contract construction. The Air Force would be responsible for determining construction and repair requirements, developing budgets to reflect those requirements and to defend the budgets (64:17). The Air Force would be responsible for directing and supervising all repairs and utilities activities at its installations (64:17). See Appendix A for the specifics of the Army-Air Force agreement pertinent to the Air Force Civil Engineering (AFCE).

Lieutenant Colonel Floyd A. Ashdown, author of an Air War College Research Report titled "A History of the Warfighting Capability" analyzed the joint agreement as follows:

> While the agreement would imply Air Force responsibility for repair of its facilities as a result of natural disasters or bomb damage, in some cases Army engineer units actually performed this function.
>
> (93:9)

Although the agreements did address "contract construction" and repair of installations, it did not specifically address troop construction responsibilities during peace or war (64:17).

The troop construction forces for constructing airbases during war was assumed to be the responsibility of the Army because according to the joint agreement:

> Except as otherwise mutually agreed upon, cross-servicing and cross-procurement as now in effect will continue until modified by the Secretary of Defense (64:17).

Since the Army had previously provided the Air Force with construction troops for wartime construction and since there were no otherwise "mutually agreed" upon arrangements, the Army would continue to provide the troop construction forces for the Air Force.

Lieutenant Colonel Ashdown suggested that there were four factors which resulted in a joint agreement which did not provide the Air Force an organic construction capability (93:10-11). First, the Corps of Engineers was already established and had troop construction forces stationed all over the world; supposedly, ready to support the Air Forces construction needs (93:10). Secondly, because the Air Forces engineering forces consisted of transfers from the

Army, the Air Force did not have an "established engineering tradition" needed to support and fight for in our construction force (93:10-11). The third factor was the public's and the Congress' emphasis on reducing the military forces and budgets (93:11). Finally, the introduction of the Atomic bomb at the close of WWII had shifted the primary emphasis from preparing for conventional wars to preparing for nuclear wars (93:11).

These factors and possibly others combined to prevent the establishment of an Air Force troop construction capability. According to Major Herman F. Engelbach, Jr., the "Army took concrete steps" to provide troop construction support for the Air Forces when it activated three engineer battalions for assignment to the USAF (79:11). These battalions were integrated into the program known as SCARWAF (Special Category Army Units With Air Force) (79:11).

SCARWAF manpower authorization and funds were provided by the Air Force (79:11). SCARWAF personnel were inducted/ selected and then trained by the Army (79:11). After initial basic and technical training, the SCARWAF units were assigned to the Air Force (79:11). This program seemed to offer little advantage over the original procedures used during WWII. While the Air Force now officially controlled the engineers assigned to them, it could not adequately control the selection and training of SCARWAF personnel.

Throughout the Korean War, the inability of the Army to adequately train, man, and equip SCARWAF units would adversely affect Air Force operations.

AFCE Status at Beginning of Korean War

As mentioned, public opinion had influenced Congress to reduce military budgets and manpower immediately following WWII. J. Lawton Collins, author of War In Peacetime, The History & Lessons of Korea, described the public opinion and Congress's almost knee-jerk-reaction to reduce the military forces and budgets following WWII by writing:

> . . . military plans and budget limitations except in wartime have invariably been in conflict. The essence of military planning is to look ahead to the requirements of the next war; but this is antithetic to the common American hope that each war will be the last. While a war is on, Congress and the people have supported unstintingly the demands of the military services but, once the war is over, political and economic pressures relegate military planning to the background . . . (44:68).

The result of such attitudes and reactions greatly reduced the military capability of all Services. Prior to the Korean War the Army experienced the expiration of the draft and the rejection of a compulsory training bill by Congress (44:67). This situation resulted in shorter enlistment periods and lower enlistment standards (44:67). When the Korean War began, 43 percent of the Army personnel in the Far East Command had been classified as Class IV or Class V (Class IV and Class V were the lowest possible categories as measured by the Army General Classifications Tests) (44:67). The Army also experienced service

deficiences in the quality and quantity of the materials and the equipment needed for war (44:67). The Air Force was also in sad shape at the outbreak of the Korean War.

General Hoyt S. Vandenberg, USAF, Chief of Staff, described the USAF in 1950 as a "shoestring Air Force" (88:65). In late 1949 and early 1950, the Air Force manpower had been cut to 411,277 personnel (88:65). There were only 2500 jet aircraft in the inventory and the majority of equipment and supplies were of WWII vintage (88:65). The U.S. military by many assessments was "hardly in a condition to wage war in the summer of 1950" (174:14). Reductions of military forces and budgets resulting from the public's hope and feelings that WWII had been the last war, greatly limited the U.S. military response to the outbreak of the Korean War (174:14).

Unfortunately, WWII would not be the last war or conflict and in the early hours of 25 June 1950, the North Koreans launched a massive and blitzkrieg type of offensive against the ill-prepared South Koreans. While operational units of the Army and the Far Eastern Air Force were undermanned, underequipped, and undertrained, they were able to operate on the first day of hostilities (88:28). The engineering battalions assigned to the FEAF, however, were not able to respond. The inability of the SCARWAF units to rapidly respond on 25 June 1950 was a "significant weakness" in offensive planning (88:58).

When the Korean War began, the FEAF engineering forces consisted of two Engineering Aviation Groups (EAG), five Engineer Aviation Battalions (EAB), and one Engineer Aviation Maintenance Company (81:1). These units were only at 80% of their authorized peacetime strength and were severely handicapped by their low experience level, a mixture of new unfamiliar equipment, old WWII equipment, and a shortage of spare parts (88:59, 81:1). While the engineering forces were only 20% undermanned according to peacetime standards, they were 46% undermanned by wartime standards (2,322 assigned versus 4,315 authorized) (88:59). The manning and equipment shortages adversely affected the combat readiness of the SCARWAF units in the FEAF.

The commanders of the 930th and 931st EAGs estimated in the Spring of 1951 that the combat efficiency of their groups was only 10 to 15 percent of what they had been during WWII. The FEAF had estimated that their engineering units had a combat readiness index of 35 percent (182:284). A survey of the FEAF engineering forces indicated that the first priority was to obtain adequate manning and sufficient operable equipment (210:31-32). General George E. Stratemeyer, Commanding General, FEAF recognized the manpower problems and requested General Vandenberg's personal assistance just to get the Army to provide enough personnel to bring the SCARWAF units up to peacetime strength.

By 28 June 1950, the invading North Korean forces had captured Seoul, the Capitol of South Korea (174:13). Three

days later on 1 July 1950, Company "A" of the 802nd EAB became the first aviation engineering force to enter Korea (210:31-32). The 802nd had been sent to improve the Yonil-man airfield for a group of conventional (non-jet) fighters (210:31-32). Before the 802nd EAB could be deployed to Korea, equipment, supplies and personnel had to be taken from other engineering forces in the FEAF to bring the 802nd EAB up to a sufficient strength. For the first two years of the war, the capabilities of the Air Force engineers was limited to constructing expedient PSP runways and repairing or extending old runways built by the Japanese during WWII (88:166). Inadequate facilities during the first two years of Korea adversely affected "every phase of operation" (150: 172). Some of the problems can be attributed to the command, control and employment of Air Force engineering units.

Control, Employment, and Organization of Aviation Engineers

A major problem during the early stage of the Korean War was the lack of an adequate engineering staff to direct, control and support aviation engineer units in the field (81:3-5). The initial airfield construction requirement in Korea was for six airfields (81:3). The Far Eastern Air Forces, possibly, because its senior leaders had remembered that engineering commands had the most effective means of controlling aviation engineers during WWII, established the First Construction Command (Provisional) on 11 July 1950 (87:7).

General E. E. Partridge, Commander Fifth Air Force (5th AF), argued, however, that he should be responsible for all Air Force units in Korea (87:7). The FEAF agreed and assigned the First Construction Command to the 5th AF (87:7, 215:no page number). To further improve 5th AF's engineering capability, General Partridge, on 15 July 1950, moved the Deputy for Installations from his subordinate position under the Deputy of Material and made him a major staff member on the 5th AF Staff (87:7). Colonel Slynn O. Mount was named as the Deputy of Installations and as Commander of the First Construction Command (Provisional) (87:5-7).

Unfortunately, while everything had been done correctly according to WWII experiences (i.e., establish engineer command and General Staff positions for Air Force Engineer), no provisions had been made to adequately staff the First Engineer Command (81:3-4). For example, only one engineer officer, Colonel William S. Shoemaker, accompanied the Advance 5th AF Hqs when it deployed to Taegu, Korea on 16 July 1950 (87:7).

The First Construction Command recorded the following remarks in its 25 June 1950 to 1 November 1950 Historical Report concerning its inadequate engineering staff:

> The failure to establish early an adequate staff controlling the aviation engineers proved to be a constant major deterrent in the construction of suitable airfields.
>
> (87:7)

The inadequately manned staff was unable to provide supervision and, more importantly, was not able to support the aviation engineer units in the field. The aviation engineer units in the field needed technical design support and assistance in obtaining construction resources (81:3-4).

In an attempt to supplement the First Construction Command's almost nonexistent staff, the 930th Engineer Aviation Group Headquarters (EAG, HQ) was assigned to Korea in August of 1950 (81:1). Upon arrival, the 930th EAG, HQ assumed control of all aviation engineer units in Korea (81:1). The 930th EAB, HQ acted as an "Architect-Engineer Firm" for the First Construction Command by reviewing all engineer intelligence; conducting reconnaissance for airfield sites; performing all field and office engineering by preparing plans and specifications; and by issuing all construction directives to the Command's EABs (75:2). No construction directive, however, could be issued until they were approved by the Deputy for Installations, 5th AF (75:2). The Deputy for Installations insured the construction directive would provide the adequate support for the operational requirements of a certain base (75:2). As one would expect, the EABs acted as the construction contractor for 5th AF (75:2). This organizational arrangement was considered too elaborate considering the manpower shortages and the volume of engineering work (175:3). Therefore, on 1 December 1950 the First Construction Comand (Provisional) was discontinued (175:2).

The general consensus was that the First Construction Command should have been converted to an FEAF Engineer Command to central intelligence forces (as originally planned) or suspended until the control of engineering activities exceeded the capabilities of the 930th EAG, HQ (175:3). The termination of the First Construction Command did serve to better delineate the responsibilities of the Deputy of Installations Staff and the 930th EAG, HQ. Unfortunately, the manpower problems for these staff were not reduced.

Fifth Air Force did manage to increase their Directorate of Installations staff (81:4-5). The Directorate of Installations Staff, however, was not able to keep up with the rapid growth of engineering forces and effort. By April 1951, the aviation engineer forces in Korea had grown to two EAGs (930th and 931st), five EABs (822nd, 811th, 802nd, 808th and 939th), and one Engineering Maintenance Company (919th). In September 1950, the Engineering Aviation Force of the Continental Air Command deployed the 809th EAB and the 622nd Engineer Aviation Maintenance Squadron to Korea (231:172). With more aviation engineer forces scheduled to arrive in Korea, it was obvious that an Engineering Brigade Headquarters was needed to control the aviation engineering activities (81:2).

During May and June of 1952, the 930th EAG (third EAG in Korea) and three more EABs (366th, 804th, and 841st) arrived in Korea (231:172). On 17 May 1952, the 417th

Engineer Aviation Brigade arrived in Korea to take direct charge of all aviation engineer units in Korea. By the end of June 1952, the aviation engineer forces totalled three Engineer Aviation Brigades, ten EABs, two Maintenance Companies, one Topographic Detachment and one Supply Point Company (81:3-4, 231:173). The arrival of the 417th had finally filled the "long standing" requirement for an adequate engineering staff to control aviation engineering effort (230:91-92; 231:173).

The 417th Engineering Aviation Brigade now acted as 5th AFs "Architect and Engineer" firm as it issued construction directives to and provided technical guidance and assistance for the aviation engineer units (231:173). The 5th AF Directorate of Installations reviewed all plans, specifications, and construction directives before they were issued by the 417th to insure they would satisfy mission requirements (88:463; 231:173). While the aviation engineers had established firm control of the Korean aviation engineer units, they were still handicapped by the inability to control the quality and quantity of new engineer troops sent to Korea.

Probably, the most perplexing and serious problems were the personnel and equipment deficiences (210:31). The Air Force, unfortunately, had no control over the training and equipping of the SCARWAF units as this was an Army responsibility (210:31; 181:1). The manning provided by the Army was inadequate. The aviation engineer units were poorly

trained and had an improper balance of supervisor and operating personnel (210:31). The Army also assigned personnel to the SCARWAF units without considering the speciality job codes of the personnel to the various positions in the EABs (210:31). This was a major problem because, the critical skilled positions were often filled with cooks and bakers (210:31). The Army had been unable to adequately man the SCARWAF units. The FEAF recorded in its 25 June 1950 through 31 December 1950 Historical Report that:

> The lesson was evident that SCARWAF engineer units upon which Air Force must depend in times of emergency should be assigned to Air Force for complete support in order that the using agency may take necessary steps to properly man, equip, and support these units (182:293).

On 17 July 1951, General Partridge sent a memorandum to General Vandenberg, Chief of Staff, USAF, describing the inadequacies of the engineer units provided by the Army (181:1). General Partridge cited that the aviation engineer effort "had been inadequate." One of the problems, according to General Partridge, was that the Air Force did not have any control of the quantity or quality of personnel and equipment assigned to the SCARWAF units (181:1). The Directorate of Installations, Headquarters USAF, had also determined that the combat effectiveness of the SCARWAF unit "was unsatisfactory" (134:14). The basic conclusion and recommendation of the Directorate of Installations and General Partridge's recommendation was the same: That full

responsibility for the training and equipping of the aviation engineers be transferred from the Army to the Air Force (181:1; 134:14-15).

Pressure from the Air Force community and the demonstrated shortfalls of the Army-trained SCARWAF units resulted in the establishment of the Aviation Engineer Forces (AEF) on 10 April 1951 (93:Background; 230:90). The AEF was placed under the command of the Continental Air Command and "assigned the mission of insuring the highest possible level of operational readiness for all aviation engineer unis in the Continental United States" (93:Background). The Army, however, still had the responsiblity of activating, manning and training all aviation engineer units (93:1). The Aviation Engineer Force would then assume control of all aviation engineer units and the responsibility of insuring that all units were in high state of operational readiness (93:1). Personnel arriving to the AEF were, therefore, supposed to be fully trained.

This was not the case. Colonel Guy H. Goodard (later promoted to Major General and served as the Director for Civil Engineering from 1968 to 1971 wrote a report titled "An Analysis of Operational Activities 1951-1956" which stated that only 23.8% of the SCARWAF personnel assigned to the AEF had received formal training (93:1). The analysis also indicated that 82.4% of the assigned SCARWAF personnel had less than five months of experience in their assigned specialty (93:1). The AEF obviously had a very formidable

problem of controlling and training all aviation engineers in the United States. The EAF did, however, manage to provide "centralized direction for the operational training of aviation engineers and its work bore good fruits in the spring of 1952 . . ." (231:172). The full integration of aviation engineer troops into the USAF proved to be a difficult and controversial issue throughout the Korean War (231:172).

Another difficult problem concerning the Army-Air Force relationship was the lack of joint participation in the development of tactical plans and training exercises. General Douglas A. MacArthur's, Commander in Chief of the Far East, staff was "essentially an Army Staff and could not under any stretch of the imagination be considered a joint staff" (82:138). This lack of an Air Force representation in MacArthur's staff complicated the most effective employment of airpower (82:138). This obviously affected all Air Force units. Undoubtedly, if General MacArthur had demanded more and better aviation engineers, he would have received a better response from the Army training center in the U.S. than did the FEAF.

The Air Force definitely had an interest in the ability of the Army to provide aviation engineering troops to support AF Operations (82:154). The lack of joint training exercise prior to the Korean War meant there were no real tests of the Army's capability to provide adequate aviation engineering troops for the Air Force (82:152).

"The Korean War pointed out vividly that the services must conduct frequent joint maneuvers both as a test of equipment and a thorough understanding of war doctrine" (82:142).

While the Air Force had an established doctrine which could be integrated with the other service doctrines, the Air Force engineers did not have an established plan of action when the Korean War broke out (134:34). The lack of a plan or doctrine seriously handicapped the USAF Directorate of Installation's planning efforts to respond to the Korean War (134:34). Even today the AFCE does not have an established doctrine. The Operation Division of the Directorate of Installations had been re-organized in March of 1950 to enhance AFCE wartime planning and training (133:12). As part of the re-organization, the Operation was redesignated as the Troop Division which was broken down into the Mobilization Planning, the Operations and Training Branch, and the Organization and Equipment Branch (133:12). The USAF Headquarters Directorate of Installation's Troop Division was responsible for:

"Troops Division: Plans, formulates and establishes policies and procedures, and exercises staff supervision, liaison and committee, representation on all matters pertaining to the development of TO/Es, utilization and equipment of engineer aviation units and installation squadrons under the jurisdiction of the Department of the Air Force. Develops, reviews, analyzes and monitors Directorate portions of war and mobilization plans." (133:12)

Despite the efforts of this Division and the contributions of the AEF, many construction problems were encountered.

Construction

Achievement and Capability. According to a USAF consultant, the quality and volume of the airfield construction accomplished in Korea was "inspite of the shortcomings . . . remarkable" (230:96). The aviation engineers built or upgraded 55 airfields during the Korean War (83:2). In the process, aviation engineers had contended with undermanned and inexperienced units, lack of adequate equipment, and supply shortages. Frequent delays due to weather, enemy activities and changing priorities also handicapped the aviation engineers. Despite such hardships, Company A of the 802nd EAB and the 822nd EAB were able to prepare expedient airfields at Pusan-West, Pusan-East, Pohang-Dong, and Taegu within the first six months of the Korean War (128:3-23). The 811th EAB began repair work on the airfields at Kimpo and Suwan on 25 September 1950 just days following the Inchon Invasion (128:13-15). The rehabilitation at Kimpo and Suwan were needed to help establish a secure beachhead following the Inchon Invasion. This was not the only dangerous and demanding work performed by the 811th EAB.

On 8 September 1952, the 811th EAB was required to resurface one-half of the runway at Kimpo while the other half of the runway was being used by aircraft (231:175). The aircraft wings sometimes "clipped the warning flags on the construction equipment" (231:175). There were, however,

no accidents. There were other noteworthy accomplishments by aviation engineering forces in Korea such as the construction of a 6015 foot runway and a 300,000 square foot parking apron in 67 days by the 366th EAB at Pusan-East (93:25). Extensive runway construction such as the 6,000 foot runway was not possible during the initial ten months of the war because of inadequately trained, manned, and equipped SCARWAF units.

Before the arrival of the 931st EAG in May of 1951, the aviation engineers in Korea were limited to performing minimum rehabilitation and upgrade of existing and inadequate Japanese bases (88:363-364; 231:173; 230:92). In fact, it was two years after the Korean War began before the first adequate (9,000 foot concrete runway) flight surface was completed at Taegu (K-2), Korea on 28 June 1952 (231:173). The only major airbase built from scratch during the Korean War was Osan-ni (K-55) in the Chinwi-Chon River valley about 40 miles south of Seoul (231:176). A primary reason why most airfields during the initial stages of the Korean War had been limited to rehabilitation of old Japanese airfields was the tremendous amount of effort and, more importantly, the time required to build a 9,000 foot concrete or asphalt runway.

Capability. According to FM 101-10, Staff Officers Field Manual, Organizational, Technical and Logistical, the time to construct an airbase was four battalion months

(177:6). This manual, however, did not specify what type of airbase (177:6) and did not consider some of the rugged conditions in which the aviation engineer experienced in Korea. For example, if the runway was to be used by fighters, cargo, and bomber aircraft, the construction time was much greater than the four and one-half battalion months it took for a simple fighter aircraft base (230:97). To build a complete 9,000 foot runway, complete with taxiways, hardstands, and runways, took eight to ten battalion months (231:182). The average time to build a 4,000 foot runway for WWII fighter aircraft took only 1.5 battalion months (231:182).

The total manpower required for the construction of an airfield is more impressive when the size of an Engineer Aviation Battalion is considered. The total strength of an EAB was 777 men (as of June 1945) (16:1-2). Multiplying the strength of an EAB by 25 working days per month and then by the battalion month needed to construct a complete airbase yields a requirement of 194,250 manhours. To satisfy the tremendous manpower requirement needed to construct Korean airfields, 5th Air Force, requested that one EAB be assigned to every Air Force operational group (230:97). The final strength of the Korean aviation engineer construction force of ten EABs was in June of 1952. Regardless of how many EABs were assigned to Korea, the environmental, geological, and climatic conditions consistently combined to delay airfield construction.

Problems of Working Environment. Korea is about one-half the size of California. The most obvious geological feature is the vast mountain ranges particularly in the North and along the East coast. The name Korea, itself, means "Land of High Mountains and Sparkling Streams" (222:5). These high mountains and streams caused many drainage and soil problems for the aviation engineer. The climate of Korea also proved to be a major problem.

Korea is located at the northern limit of the monsoon belt. Therefore, during the summer months, the aviation engineers in Korea experienced torrential rains. Rainfall in Korea varies from 20 inches per year in the North and 60 inches in the South (10:12). The combination of these heavy rains, mountainous terrain and the presence of clay type soils created some very difficult drainage problems for the aviation engineers.

The mountains limited airfield construction to the flat valley areas. Unfortunately, the soil in these valleys was composed of clay and of decayed vegetable matter resulting from decades of rice cultivation (5:1). The water table in these areas was generally one to three feet below the surface (5:1). The combination of the clay and decayed rice paddy vegatation found in these valley areas was called "paddy soil" (231:176). The "paddy soil" was very unstable and excavations of up to 15 feet were required to provide an

adequate runway base. Extensive drainage was also required to prevent the torrential rains from eroding and saturating the airfield subbases.

The WWII experiences of the problems associated with inadequate drainage were forgotten or discounted. Fifth Air Force's initial construction policy directed that all facilities were to be constructed for a six-month life. Little effort, therefore, was taken to provide the extensive drainage structures and/or to remove the unstable "paddy soil" (5:TAB A-4). Even when the Air Force vocalized that more permanent type construction would be needed, inadequate drainage continued to result in airfield surface failure. A USAF consultant stated that as late as August 1951 most EABs did not have sufficient understanding of soil compaction, subsurface drainage and runway surfacing (230:90). Airfields continued to fail due to inadequate drainage and compaction. The entire asphalt runay at Kunsan deteriorated beyond use on 18 April 1952, only three days after it had been completed. The primary cause for deterioration was inadequate drainage and soil preparation (230:94). The subfreezing temperature during construction had damaged the asphalt and, thereby, was a contributing factor to the Kunsan runway failure (230:94).

Although Korea is located on about the same latitude as San Francisco, Wichita and Philadelphia, the Korean winters are much more severe (174:1). The 811th EAB recorded on 11 February 1951 that the extreme cold made living conditions

extremely uncomfortable and delayed all earth and asphalt work (118:1). The November 1951 Historical Report for the 802nd EAB indicated that out of 30 working days in November 1951, 12 days were lost becuase of inclement weather (109: 12). Later in January 1952, the 811th EAB's construction projects were delayed by frozen ground down to depths of one and a half feet (120:1). The 839th EAB recorded the frozen ground in February of 1952 "hampered" taxiway and apron construction (123:1).

Another hinderance to construction was the local South Koreans frequent practice of damming vital airfield drainage ditches to supply water for their rice fields (124:2, 126: 2). The areas most suitable for airfield construction were also the most suitable for rice fields and local villages. In many cases, the construction of airfields required the relocation of entire villages. Airfield construction at Pyong-Taek (K-6) required the relocation of five villages (231:176). Although the nearby villages supplied an immediately available labor force, this labor force was primarily limited to "pick and shovel" type work (75:6). Interpreters were required to provide effective communication with the South Korean laborers (75:6). While there were plenty of local laborers, many construction materials were not readily available.

Gravel for base materials and concrete aggregate were very seldom available within the immediate vicinity of the airfield site. The gravel, as in the case of the 839th EAB

working on the Osan airfield, had to be quarried and then hauled many miles to the airfield site (127:8). Aviation engineers also had to establish and operate their own concrete and asphalt plants. Construction requirements were delayed and were more extensive because of the inadequate commercial power systems.

The electrical power distribution systems in Korea were subject to frequent failures (230:96). The lack of a dependable commercial power supply was a serious problem as an average base required 300 to 500 KVA (231:79). This power requirement was more than could be supported by the available generators at any particular base (231:179). The available generators varied in make and sizes ranging from 5KW to 30KW (83:13). The generators themselves were very unreliable. The innumerable types and sizes made it very difficult to provide the spare parts needed for maintenance. The most pressing problem at the beginning of the Korean War, however, was to quickly provide expedient airfield landing surfaces for the much needed fighter and cargo aircraft.

Runway Surfaces and Aircraft Arresting Barriers. Pierced Steel Plank (PSP) was the primary expedient runway surfacing material during the Korean War. During the initial months of the war, there was an immediate requirement for fighter aircraft to support the hard pressed ground forces. In turn, there was an immediate requirement to rehabilitate and maintain the few remaining airfields

controlled by the United Nations (UN) forces in South Korea. There was also an urgent need for the construction of some new airfields. The urgent need for airfields and the limited construction capabilities of the three EABs in Korea resulted in a tremendous requirement for PSP.

Although PSP had proved to be a valuable and essential asset during WWII, the USAF had very little in stock at the beginning of the Korean War (137:3). Emergency requests were made for PSP. On 1 July 1950, the FEAF requested 5,000,000 square feet (SF) of PSP from HQ USAF. This requested PSP was needed to supplement the approximate 5,000,000 SF that had been collected by the FEAF (182:286). The requested 5,000,00 SF of PSP was delivered to Japan in just 24 days (182:286). By 15 September 1951, 7,611,000 SF of PSP had been installed at Pusan-West (K-1), Taegue (K-2), Pohang (K-3), and Pusan-East (K-9) (182:286). In early December 1950, the stock levels of PSP were "exhausted" because of loss to enemy advances and unexpected emergency requirements (210:34-35). An additional 10,000,000 SF of PSP were used in the Korean War (182:286).

While the PSP performed well as an expedient airfield surface, it soon began to deteriorate due to the heavy loads, inadequate drainage and soil compaction, and the frequency of use. General Ferguson stated that many of the problems experienced with PSP were caused by the fact that it had been considered a complete runway and not a runway surface (230:98).

There were many other disadvantages to using PSP runway surfaces. First, the PSP was very expensive, costing about \$7.50 per plank (5:2). In fact, it was estimated that a concrete runway which was 150 feet wide by 9,038 feet long cost about \$154,560 while a PSP runway of the same dimension would cost \$759,192 (based on a unit PSP cost of \$7.00 per plank) (5:TAB C-3). The maintenance efforts and costs to keep the PSP useable were staggering. During the last two months of operation of the PSP runway at Taegu, an average of 250 to 300 PSP planks were replaced every 24 hours (5:TAB C-4). This equated to an expenditure of \$1,750 to \$2,100 for PSP each day (5:TAB C-4). In terms of manpower it took approximately 25,000 manhours each month to maintain the PSP runway (83:5). More important were the operational costs due to aircraft damage resulting from PSP runways. While operating from the PSP at Taegue in May 1952, the average life of F-84 tires was 5.2 landings (5:TAB C-1). Operating F-84 aircraft from a concrete strip at Taegu during July 1952 resulted in an average tire life of 29 landings per tire (5:TAC C-1). The cost of an F-84 tire was \$54.00 in 1952 (all costs quoted have been based on value of dollar in early 1950s). Based on this cost, the average savings per landing was calculated to be \$1,86 per landing.

The rough PSP surfaces were not only hard on aircraft tires; they also caused severe structural damage to aircraft. During operation in April and May 1952, an average

of four aircraft wings were replaced bacause of damaged spars, damaged leading edges, and wrinkles in the wing (5:TAB C-2). While operating off concrete runway, only one wing per month was changed (5:TAB C-2). This yielded a monthly savings of $45,362.25 as aircraft wings cost $15,120.75 each (5:TAB C-2). During a two month period from February through May 1952, the 49th Wing at Taegu lost four aircraft at a cost of one pilot's life and $600,000 (5:TAB C-2-3). The rough surface of the PSP runway was cited as a primary cause in all four accidents.

The rough surface of PSP runways result in severe vibrations and a high noise level which in many cases masked potential engine problems during take-offs. The irregular surfaces of the PSP also created a tremendous amount of drag on the aircraft. Finally, the irregular PSP surface did not provide a very good braking service. The PSP, however, was the only proven expedient airfield surfacing material.

While a conrete runway (150 feet wide x 9,000 feet long) took 44 days to construct, a minimal operations PSP runway could be built in 30 days (5:TAB C-3). PSP matting could also be prepared if damaged by enemy bombing or mortar attack. The general recommendation that came out of the Korean War concerning airfield surfaces was that PSP was needed for expedient or temporary construction in combat areas (5:TAB C-7). If flying operations were to continue

for a substantial period after the expedient PSP surface was built, a concrete runway surface should be constructed (5:TAB C-7). The inadequacies of PSP to support jet operation was recognized and General Partridge wrote in a 17 July 1951 memorandum to General Vandenberg, Chief of Staff USAF, that:

> Development work on airfield design and on air installations to keep the AF ground plants abreast of the aircraft is urgently needed and this is a vital AF responsibility. As example, pierced steel plank is inadequate for jet aircraft runways for several important reasons yet no substitute is in sight.
>
> (181:2)

The research and development of expedient runway surfaces, because of the tremendous stockpiles of PSP remaining after the Korean War, was discontinued (138:4).

One important development which took place during the Korean War was the implementation of aircraft arresting barriers for land based runways. Although flight safety records had improved somewhat with the introduction of longer runways, many aircraft mishaps continued to occur because of aircraft failing to stop during emergency landings or to successfully abort take-off rolls before travelling past the end of the runway (231:122). During the period from 1 October 1951 to 31 August 1952, 29 such aircraft mishaps occurred (14 failed to land, 15 failed to abort take-off) (231:122). These mishaps prompted FEAF

officers to visit the aircraft carrier, USS Princeton, in September of 1952 to investigate the potential of using an aircraft barrier to prevent aircraft from running off the runway during landing and take-off (231:177). A version of the Davis barrier was determined to be the most suitable for Air Force needs (231:177). The barrier was held in position by two retractable stanchions on opposite sides of the runway. The aircraft would "engage" the barrier which was connected to heavy anchor chains (each link weighed 67 pounds). These massive chains were layed along both sides of the runway (231:177). The weight of these massive chains caused the engaged aircraft to decelerate, thus, stopping the aircraft from overshooting the runways (231:177).

The first model barrier was tested at Johnson Air Force Base in Japan on 6 and 7 February 1953. The barriers were first installed at Kimpo's runway and on 25 April 1953 these barriers successfully engaged two RF-80s under emergency condition (231:177). Barriers were also installed at Taegu, Suwan, and Osan (231:177). Three $200,000 F-84 aircraft were saved from sure destruction by the aircraft barrier installed at Taegu within the first two weeks (231:177). The return on the barrier construction costs was over eleven to one as the barrier cost only $17,634 to install (231: 178). By December of 1953, the track record at Taegu of the barrier was as follows:

36 Total barrier engagements
8 Planes received no damage
21 Planes received minor damage
7 Planes received major damage
1 Pilot seriously injured

(231:178)

The obvious saving in aircraft, men, and money prompted the FEAF to forward recommendations to HQ USAF that aircraft barriers be installed at all world-wide fighter bases (231:178). Unfortunately, in many cases the saving returns on the Air Force construction costs were not as favorable as they were with the barriers.

Construction Plans, Policies and Trends . From 1945 until the outbreak of the Korean War in June 1950, the funding for the maintenance of Air Force facilities had been less than adequate (134:34). The entire Air Force's inventory of facilities had suffered from this drought of maintenance funds (133:29, 135:31). After the North Koreans invaded South Korea, a tremendous increase in funds was made available for airfield construction and upgrade (134:34). The lack of a pre-established plan or doctrine severely handicapped the initial efforts of the planners and programmers of the Directorate of Installations, HQ USAF.

A major concern in the allocation of resources to Korea was the fear that the North Korean invasion was just a "smoke screen" or distraction for an impending Communist assault in Western Europe (44:78, 134:17). The Directorate

of Installations, HQ USAF estimated that 169.7 million dollars would be needed to provide facilities for Korean hostilities and rehabilitation of airfields in Western Europe in case of Communist agression in Europe (134:17). Adequate planning was also hampered by inaccurate records and data on the conditions of Air Force facilities (134:17, 136:14). Despite these handicaps, the Directorate of Installations, HQ USAF was able to immediately fund FEAF's request on 7 July 1950 for five million dollars to build six advance airfields. On 11 July, the FEAF requested an additional two million dollars for Korean airfield construction. Again, their request was processed and approved within a matter of a few days (134:4). The Directorate of Installations also obtained an increase in the project approval authority for the FEAF. This reduced construction delays by decreasing the number of projects which had to be sent to Washington for approval (210:19). The massive and rapid increase in construction requirements and the subsequent increase in authorized construction funds required close coordination be maintained between the Directorate of Installations, HQ AF, FEAF and Deputy for Installations, 5th AF (210:21).

To insure that 5th AF's engineering resources were properly managed, the Deputy of Installations approved all construction directives. The experiences of WWII had indicated that a construction policy was an essential tool for enforcing the most effective resources. During the

initial stages of the Korean War, there appeared to be no official/published construction policy. Fifth Air Force, however, issued individual construction directives to each EAB. The primary policy called for expedient and temporary construction standards (83:1). The construction standards were based on the effort and materials needed to build an airfield with a useful life of only six months.

Vital construction procedures such as excavation of paddy soils and proper soil compaction were omitted or reduced. Drainage structures were also given little consideration (83:1). As a result, many of the airfields required constant and costly maintenance as the war progressed. The temporary PSP surfaces and the PSP/asphalt surfaces also caused extensive damage to aircraft valued at ten million dollars (210:22). The inadequate airfield surfaces also restricted operational activities. Combat loads for the aircraft were cut to 50 percent of their peacetime capabilities to insure they could negotiate the rough surfaces of temporary runways (210:22-23).

General Partridge recognized the problems with the temporary construction standards, which in most cases resulted in reaccomplishment of the work. In order to eliminate this wasteful practice, General Partridge directed the 5th AF Deputy of Installations to ". . . build the best establishment you can and assume you will be staying there" (88:363; 230:89). General Everest continued and even extended the policy when he directed the construction of 9,000 foot

runways at Taegu, Kunsan, and Suwan airfields (133:363). These 9,000 foot runways were more expensive to build than the expedient runways which were generally 3,500 feet to 4,000 feet long (133:363). The expedient runways were also cheaper because less engineering effort had been expended on soil preparation and adequate drainage structures. The long term savings incurred from less runway maintenance, less aircraft damage and the elimination of jet assisted take-off (JATO) bottles (needed by aircraft operating from short fields) indicated that for permanent or semipermanent operations longer airfields were more economical. The general trend of airfield construction usually had three distinct phases. First, a 3,500 to 4,000 foot PSP runway with minimum parking aprons, taxiways and drainage was constructed just to get the airfield operational (75:11). Second, a 7,000 to 9,000 foot runway and more parking were built (75:11). The third phase consisted of constructing complete drainage systems and perimeter or access roads (75:11).

After reviewing the airfield construction problems experienced during the first year of the Korean War, the 5th AF Deputy of Installations determined: "That a complete standard criteria for construction of air Theater of Operation bases" should ". . . be developed" (75:18). It was recognized that the plan had to be both standard and flexible (75:18). On 25 September 1951, a copy of the "construction criteria for Korean Theater of Operation airbases" was sent to all agencies which would be affected by this

construction policy (129:11). Finally, one year and three months after the beginning of the Korean War a construction policy had been established. This construction policy greatly enhanced the development of base master plans.

Experience during Korea indicated that base master plans should be a Command function because, the installation units would develop plans suited only for their existing operational mission (75:18). The aviation engineers of the base installations would often neglect the possibility for mission changes or expansions (75:18). For the most part, master planning, during the Korean War, was inadequate (231:183). In fact, the only airfield which had been built on the basis of a second master plan was Osan-ni. Osan-ni was developed in such a manner that future expansions or changes could be easily accommodated.

Expansions, changes in mission, and upgrades of airfields were a common occurrence during the Korean War. It was considered a "fallacy" to construct an airfield solely for fighter aircraft as inevitably heavier bomber and cargo aircraft would use the airfield (177:7; 175:23). Mission changes were not the only reasons longer and stronger airfields were needed in Korea.

A common mistake made by aviation engineer planners was the disregard for the increased weights of aircraft resulting from the additional fuel and munitions demanded by operational requirements (182:292). Because the airfields were constructed without consideration given to combat loads of aircraft:

> . . . Combat aircraft, especially fighters, have never been able to take off with their full combat load in Korea. The F-80s which are equipped to carry 8 rockets (and 2 tanks of napalm if pylons are installed) normally carry 2 or 4 rockets and sometimes 2 tanks of napalm (175:23).

Another common mistake was the miscalculation of how many sorties would operate from a certain airfield. Many pavement design curves were based on an average of 3,000 landings per month, while Korean airfields experienced up to 10,000 landings per month (230:91). The base master plans must also allow for the increase in creature comfort requirements.

Prefabricated Facilities. As the combat situation stabilized, there was a ten-dency to increase creature comforts (83:11). Primitive tents were replaced with a more permanent type of facility (83:11). The tropical shell was one such facility. The components of the tropical shell facilities were made in Japan and shipped in packaged kits to Korea (83:11). The basic components of the tropical shells were prefabricated wooden frames and sheets of metal or wood which were used as the roofing and siding. These tropical shell kits were easily configured into varying layouts and the prefabricated frames allowed unskilled workmen to rapidly erect these facilities (83:11). There were two problems with tropical shells. First, these facilities were designed for a two year life expectancy. The wooden frame and siding quality deteriorated in the Korean environment. This resulted in a

constant requirement for maintenance. Second, the tropical shells had to be "winterized" (insulated) to protect the occupant from the cold.

The metal prefabricated Quonset hut provided a more "maintenance free" facility and it had a five-year useful life expectancy (83:12). The Quonset huts, however, could not be as easily configured as the tropical shells were (83:12). Insulation kits were required for the Quonset just as they were for the tropical shells.

The other basic type of facilities were wooden framed, and stucco covered buildings with corrugated metal roofs. These facilities were built by local contract labor. While these stucco huts were quick and cheap to build, they required constant maintenance (83:13).

Prefabrication of facilities became a major point of interest during the Korean War. On 8 February 1951, the Office of the Tactical Air Research and Survey (TARS) completed its study on the effectiveness of prefabrication methods (42). This report concluded that the use of prefabricated structures and facilities would eliminate the situation of "starting from scratch" (178:2). Manpower and local materials could be used for other requirements (178:2-3). The report warned, however, that careful consideration should be given to the availability of transportation which was often overtaxed and not available to items such as low priority construction supplies (178:3). According to the report, the amount and quality of training received by

engineering units on erecting prefabricated structures should also be considered (178:3). Overall, the report concluded that prefabrication could be used "advantageously" to construct buildings, PSP runway and POL (Petroleum, Oils and Lubricants) tanks and facilities (178:3).

The development of POL facilities was considered by the FEAF to be one of the most essential airfield construction requirements (83:205). The fuel requirements of the high performance jets and long-range bombers were three times higher than that of WWII aircraft (135:32). The introduction of jet fighters into the Korean War resulted in average daily fuel demand of 125,000 gallons of fuel (231:202, 88: 364). At the Suwan airfield, aircraft were manually fueled from 55-gallon drums (88:171). The Army and the Air Force had recognized the need for POL facilities to avoid the manual refueling from barrels at the beginning of the Korean War (83:9). However, POL construction materials did not arrive in Korea until one year after the war began (83:9). Even when the equipment arrived, construction delays occurred due to the lack of standardization (83:10). Often, POL construction parts made by one manufacturer were not interchangeable with those of another manufacturer (83:10). This same problem had been experienced during WWII and according to the FEAF ". . . recommendations made at that time to correct this type of deficiency apparently were forgotten" (83:10).

POL systems were not the only utilities which were in high demand. The average water demand for an airfield was 300,000 gallons of water per day (83:13). The water demands at some bases were even higher. For example, the 67th Tactical Reconnaissance Wing at Kimpo increased the water demand to 500,000 gallons of water per day (231:179). A common problem was the inability of the pumps to operate to their rated capacity (83:13). The pumps were not designed to pump the typical stream and well water which was laden with suspended solids (83:13). The pumps were also powered by high speed engines which were unsuitable for extended operations and required constant maintenance. The high demand for electrical power also presented problems for the engineers. A typical base required, as stated previously, 300 to 500 KVA of electrical power (231:179). The unreliability of Korea's commercial power systems and the USAF's inadequate generators proved to be a constant and serious deterrent to effective operations. Again, like the water pumps, the generators suffered from lack of standardization and durability (180:96). Many of these utility requirements were the result of increasing support needed by the more modern aircraft which had been introduced into the inventory following WWII and even during Korea.

Increasing technology greatly enhanced the capability of combat aircraft. However, the heavier and faster aircraft caused many construction problems for the aviation engineers of the Korean War. Introduction of the faster jet

aircraft resulted in an increase from a WWII maximum of 80 pounds per square inch to 200 pounds per square inch for Korean era aircraft (231:182; 230:97; 13:89). The wheel load of the C-24 used in Korea was approximately 54,500 pounds compared to the 15,000 pounds of the C-47 used in forward areas during WWII (4:23). As indicated in the following table, the F-84 (Korean Era) required more than three times more runway than the F-51 (WWII Era) (4:7).

TABLE II

Comparisons of WWII and Korean Era Aircraft

	Aircraft	Gross Weight	Max Tire Pressure	Runway Length as MSL Emergency	Full Ops
FIGHTER	F-51*	11,000	73	1800	2600
	F-80	15,336	139	3900	5400
	F-84	16,329	109	5800	8000
	F-86	17,015	165	3100	4300
	F-94	16,000	155	4000	5600
CARGO	C-46*	44,000	78	3500	4900
	C-47*	30,000	63	2500	3500
	C-54	73,000	94	4600	6400
	C-119	71,800	79	2800	4000
	C-124	208,000	75	6400	9000
BOMBER	B-26*	40,015	59	4900	6800
	B-45	113,000	200	8700	12,400

* World War II Aircraft

As already mentioned, the manpower required to construct an adequate 9,000 foot concrete runway for the Korean Era aircraft was about 4.5 battalion months (231:192). The manpower required to construct a 4,000 foot runway needed for most WWII aircraft was only 1.5 battalion months (231:182). According to 5th AF's review of airfield construction and the related problems experienced from 1 July 1950 to 31 May 1951 during the Korean War:

> With the advent of heavier, larger and higher performance aircraft, the engineering planning, design and field supervision involved in the preparation of facilities for operation of these aircraft will become more and more critical, necessitating a growth beyond the efficient administrative and managerial capabilities of the already heavily committed primary staff function of the Deputy for Material.
>
> (75:21)

Not only did the rapidly developing technology increase the required construction effort, technical support, and managerial support, it also increased the maintenance requirements for Korean air bases.

Maintenance Policies. According to the 5th AF's construction policy (Criteria for Construction of Korean Theater of Operation Air Bases, 16 September 1951), the USAF was responsible for:

> The construction, reconstruction, rehabilitation, repair and maintenance of air bases, including all appurtenances thereto required exclusively or predominantly by the USAF in carrying out its assigned missions in Theater of Operation . . .
>
> (5:TAB D-1)

The original maintenance concept called for Air Installation Squadrons to assume air base maintenance as soon as an EAB finished their construction tasks (231:123; 75:TAB D-3). Fifth Air Force, however, sometimes directed EAB units assigned to an installation to perform maintenance (230:97). Many of the EABs argued that dividing the units on very small projects was not the best use of their capabilities (230:92).

On the other hand, many of the Air Installation Squadrons were required, generally out of necessity, to perform major construction tasks which were beyond their capability (75:3). The Air Installation Squadrons were forced to work on facility and even runway construction projects (75:3). In many instances, the Air Installation Squadrons and the EABs worked side-by-side on maintenance and construction projects. Although these units worked well together, the integration of the two units "disguised" personnel and equipment problems that required attention (75:4). Another problem concerning the Air Installation Squadrons was that the majority of the personnel had acted as supervisors in Japan. When they arrived in Korea, however, they lacked the experience and technical knowledge to actually operate the equipment and do the work (75:4).

The first Air Installation Squadrons arrived in Taegu, Korea on 17 July 1950 (75:3). This unit remained at Taegu until 1 August 1950 when it transferred to Asiya, Japan (75:3). This Air Installation Squadron was reorganized and

then returned to Korea as an integral part of the 6022nd Tactical Support Wing (75:3). The Air Installation Squadron of the 6022nd Tactical Support Wing was the first complete Wing/Installation Squadron combination in Korea (75:3). The number of Air Installation Squadrons eventually grew and did an excellent job in maintaining over 20 major installations during the Korean War (93:30). The maintenance responsibilities were more defined in the Korean War than in WWII, where the maintenance was accomplished by many different and varying organizations. These Air Installation Maintenance units were also controlled by the Air Force Wing Commanders. There were also some improvements made in the area of reconnaissance and intelligence.

Construction Intelligence. During the first week of July 1951, an inspection was made by installation officers at all U.N. held air bases. This inspection indicated that the existing intelligence on Korean airfields was "inaccurate, outdated, and based on reports of non-technical personnel" (210:33). The first requirement of the aviation engineer was to collect information on potential sites to enhance airfield site selection procedures (210:19). Preliminary map and aerial reconnaissance was first conducted. Then a study of aerial photographs was conducted to select potential airfield sites. If time allowed, ground reconnaissance was conducted (75:8).

The Aviation Engineer Force initiated a program to collect worldwide engineering intelligence data on overseas

air bases and some air bases in the U.S. This information was used to develop "target folders" for these bases (93:Chapter 7-32). These "target folders" contained the following pertinent information:

> . . . area maps, basic plans of facilities and utilities, meteorological data, airfield evaluation, soil conditions, topography, flight hazard detail, security conditions, political aspects, local resources (labor and materials), logistical problems and any other information of value to a construction unit which might be moving onto the site or in the area for construction or rehabilitation (93:Chapter 7-32).

This information was obtained from the:

> Office of Naval Intelligence, USAF Intelligence, USA, Office Chief of Engineers, Vicksburg Waterways Experiment Station, Central Intelligence Agency, American Map Service, Aeronautical Chart and Information Center, MATS Airfield Surveys, debriefing of overseas veterans, and answers from questionnaires submitted from aviation engineer units overseas (93:Chapter 7-33).

This intelligence information gathering process represented a major improvement over the intelligence systems employed by the AAF in WWII.

An internal mode of transmitting intelligence was begun in August 1952 (93:Chapter 7-30). This internal mode of communicating engineering intelligence was called the Aviation Engineer Technical Bulletin. Three volumes of the Aviation Engineer Technical Bulletin were published and distributed to all aviation engineer organizations and to other interested professional agencies, schools, and military commands (93:Chapter 7-33). While improvements had occurred in the area of engineering intelligence and

reconnaissance, problems with construction equipment plagued the aviation engineer from the beginning to the end of the Korean War.

Equipment

Many equipment problems occurred during the Korean War, particularly for the first year (177:1). According to a TARS report (Report No. 34, Airfield Construction Equipment: Analysis of Its Adequacy During the Tactical Air Operations in Korea 25 Jun-1 Nov 5Ø) the primary equipment problems during the first few months of Korea were:

a. Insufficiency of construction equipment in this theater at onset of hostilities.

b. Spare parts and re-supply "bottle necks."

c. Poor maintenance of existing construction equipment.

d. The gross inadequacy of the Korean roads and railways over which equipment must be transported

(177:1)

When the Korean War began, the levels of heavy equipment possessed by the EABs were 4Ø percent below the authorized amount of equipment (177:1). Most of the equipment was of WWII vintage and was generally in poor condition (231:181; 177:4). The Depot equipment stocks were low and as the equipment already possessed by the aviation engineer units was in poor repair (177:4). In an attempt to alleviate this problem, modern heavy equipment was sent to the Korean Theater. Unfortunately, the spare parts of the old

WWII equipment and new equipment were not interchangeable. This led to a tremendous spare parts requirement (231:181).

Equipment shortages were so acute at the beginning of the Korean War that in order to properly equip "A" Company of the 802nd EAB (first aviation engineer unit in Korea), many pieces of heavy equipment had to be stripped from the other FEAF units (182:285). When the 822nd EAB was ordered into Korea on 10 July 1951, the other FEAF units on Okinawa were again stripped of their equipment so that the 822nd EAB could be properly equipped (182:285). The equipping of the 822nd EAB by stripping other units depleted the equipment level of the FEAF to a point that immediate deployment of units from Okinawa was a "physical impossibility" (182:285).

The 811th EAB, therefore, experienced many problems replacing their "tropic weary equipment, which had been in use, generally since WWII" (120:1). The 811th had to travel from Guam to Japan where they acquired some needed equipment. The 811th EAB was deployed on 24 September 1950 to rehabilitate the Kimpo airfield following the invasion of Inchon (116:2). The equipment shortages continued through 1951 and were considered to be a "detriment" to airfield construction (230:96).

The struggle for adequate equipment continued into 1952. In March 1952, the Eighth United States Army Korea (EUSAK) requested that all unauthorized pieces of equipment held by 5th AF's EAGs be returned to the Army (176:1). Fifth Air Force took immediate action in an attempt to

retain the equipment as many of the aviation engineer units were still under equipped (176:1). For example, the 839th EAB reported in its June 1952 Historical Report that they only had just over 50 percent of the equipment required to perform their assigned tasks (127:8). The 839th had recorded in their April 1952 Historical Report that the equipment problems were the results of equipment shortages, inexperienced operators and lack of spare parts (126:1). The excerpt below describes the 839th EABs predicament in April 1952.

> Asphalt Distributors are at a premium, the one assigned can be turned in but it is needed so badly at K-14 that paper gaskets are being used on the sprinkler bar. Thermometers are needed for it but this problem has been overcome. The thermometer case is inserted in the well, if a man can hold the thermometer in his hand after it is extracted from the well the asphalt is 200o F, if he can just barely hold it, it is about 250o F and if he can't hold it at all it is 300o F or over. These are just a few of the equipment problems that have been occurring so long that they are more or less being accepted as an operational evil that is a taken for granted hazard.
>
> (126:1-2)

While the EABs were assigned high priority and heavy equipment intensive projects, the in-commission rates for some EABs ranged as low as 0-15 percent for critical equipment items (81:8-9).

The lack of experienced operators contributed to these low in-commission rates. According to one report, very few of the operators assigned to the EABs had more than a two-week "familiarization course in observing the operations of

engineering equipment" (177:20). The result was inefficient operation, a high accident rate, and vehicle abuse (81:9, 177:20). The vehicle abuse of equipment resulted in permanent damage and excessive maintenance requirements. For example, a bulldozer when operated in a careful and correct manner required depot overhaul after 20,000 hours (177:20). The average time between overhauls in the early months of the Korean War was between 2,000 and 3,000 hours (177:20). A recommendation made by the Office of Tactical Air Research and Survey (TARS) concerning the development of future equipment was not to assume the ideal condition of experienced operators, an expeditious logistical channel, and experienced maintenance personnel will exist in future wars (177:3).

The maintenance personnel, like the equipment operators, were generally inexperienced and untrained. According to TARS Special Report No. 34, the "quality of maintenance" for equipment could "best be described as spotty" (177:5). One of the reasons for the spotty maintenance was the lack of maintenance personnel. The 822nd, for example, had only 50 percent of their authorized diesel mechanics (authorized 14, assigned 7) (177:21). The lack of adequate maintenance facilities also curtailed effective maintenance, particularly during the winter months. Maintenance personnel were in many cases forced to work without proper facilities such as lube racks. They were also frequently forced to work in adverse conditions such as mud, rain, snow, and extreme cold

because there were either no facilities or the facilities were inadequate (81:9, 123:7). Naturally, this situation curtailed much needed maintenance (81:9).

As mentioned, the shortage of spare parts was a major problem concerning the maintenance of equipment. According to the February 1952 Historical Report for the 839th EAB:

> Supply of spare parts for engineer and ordnance equipment has been very poor. There were approximately 50 percent of our equipment deadlined for the lack of spare parts (123:7).

Conditions did not improve in April 1952 as the 839th could operate only four of their nine D-8 dozers and nine out of their fifteen Tournadozers (231:181). In early February of 1953, 65 percent of the 839th EAB's Caterpillar tractors and Tournadozers were inoperable because of an inadequate supply of spare parts (231:18). A common but undesirable solution to the shortage of spare parts was the cannibalization of one piece of equipment to supply a spare for another piece of equipment (177:5). Equipment parts were not the only form of supply problems for vehicles. Shortages in lubricants and oils were common and induced additional maintenance. Supplies such as antifreeze were also in short supply. Many vehicles of the 808th EAB could not be winterized during the winter of 1951 (November 1951) because of the shortage of antifreeze. The water, therefore, had to be drained from the equipment every night and then replaced the following day (113). Lack of spare tires and front springs was also a problem for the EABs.

The lack of equipment standardization further complicated the spare parts problem by introducing requirements for more and different types of equipment (81:11). Not only were supply requirements increased; but equipment operators and equipment personnel were forced to learn unique operating and maintenance procedures of each new piece of equipment (81:11). Training requirements to learn the new equipment systems and/or equipment damage increased with the number of different types of equipment.

As already mentioned, the equipment possessed by the EABs in the FEAF at the beginning of the Korean War was primarily left over WWII equipment. In the spring of 1952, emergency requisition of equipment began arriving from the states (88:365). The spares of the new equipment were interchangeable. According to "An Analysis of Operational Activities: Aviation Engineer Force", the standardization problem (the lack of standardization) was:

> A result of the procurement policy established by law, whereby construction equipment as long as it met specifications, would be purchased from the lowest bidder (93:39).

The lack of standardization affected every type of equipment item from heavy earthmoving equipment to water pumps to generators. The Aviation Engineer Force (AEF) noted that the lack of standardization had an "appalling impact on the Forces" (93:28). The lack of generators standardization, for example, caused the aviation engineers many headaches.

The unreliable commercial power system of Korea made it necessary for all bases to have stand-by electrical power (83:13). A primary problem with generators was the numerous types and sizes of generators. Generator sizes ranged from 5KW to 300KW (83:13). To make matters worse, these generators had high speed/high RPM engines which equated to frequent maintenance and a large demand for non-standard parts (83:13). When one considers that an individual aviation engineer unit was authorized four generator sets and that those generators could have been made by any of nine possible manufacturers, it is obvious that unless the parts of the different types of generators are interchangeable a tremendous spares problem was inevitable (93:29). As it was, the degree of interchangeability of spare parts average one to six percent (93:29).

There were many recommendations to improve the equipment situation for the aviation engineer. The key recommendations, however, appeared to be:

1. Insure the aviation engineer equipment "keeps pace" with the equipment improvements/advances made in the civilian community (93:27).

2. Avoid multipurpose equipment. Keep it simple (93:27).

3. Standardize as much as possible (93:27, 177:3).

4. Increase size and mobility without increasing generator requirements (177:3).

Logistics Support

While reviewing the unit histories of EABs serving in the Korean War, the authors found that, almost without exception, the number one supply problem was the shortage of spare equipment parts. The 839th EAB, for example, recorded in their May 1951 historical report that the most difficult supply problem was obtaining spare parts for engineering equipment (121:8). The Major Command Histories also indicated the severity of the supply of spare parts problem. The FEAF wrote in their 25 June to 31 December 1950 Historical Report that "material shortages was one of the most pressing" problems experienced by the SCARWAF Engineer Aviation Battalion during October 1950 (182:292). During the first two months of the Korean War the inadequate resupply of spare parts deadlined heavy equipment (75:15). Frequently, it was more expedient to salvage equipment with minor damages and requisition new equipment than to wait on spare parts (75:15). Ten months after the beginning of the Korean War, the resupply of spare parts was considered a critical problem (75:15). In the spring of 1953, a program named CRASH was initiated to acquire essential equipment and spare parts needed to support the airfield construction program (231:181). As part of CRASH, the 5th AF sent representatives directly to the Columbus General Depot in Columbus, Ohio to obtain the needed equipment and supplies (231:181). In many cases, only the "foresight" of the EABs

to carry an "extraordinary" amount of spare parts when deploying from Japan to Korea allowed the units to function at all (117:7).

The shortage of heavy equipment spares was not the only supply shortage problem experienced by the aviation engineers in Korea. At the beginning of the Korean War (just as in WWII), the procurement and transportation priorities assigned to construction materials were much lower than those given to war materials (munitions, aircraft spares, and fuel) (75:16). This resulted in the procurement of almost all construction supplies from the local community (75:16). As the war progressed, the supply of construction materials improved (75:16).

As in WWII, there were many problems experienced in the transportation support provided to the aviation engineers. One significant improvement in the logistical planning over that in WWII was the fact that the aviation engineers had representation on the 5th AF General Staff in the form of the Deputy of Installations. This allowed the Deputy of Installations to directly provide the 5th AF Commander with the needs of aviation engineers and their capabilities to support tactical operations (75:21). Even with this improved representation, the aviation engineers experienced logistical problems.

One such problem occurred at Kimpo airfield immediately following the Inchon Invasion. The 811th EAB was responsible for repairing the field at Kimpo. However, the 811th

EAB was not unloaded at Inchon until ten days after the invasion (182:294). This delay in scheduling resulted in the unnecessary delay of the rehabilitation of Kimpo and the subsequent delay in activating air operations needed to secure the Inchon bridgehead (182:294).

The whole deployment of the 811th EAB had been marked by logistical problems. When the 811th EAB deployed from their home base in Guam to Japan, it travelled separately from its "housekeeping set" (116:1). The 811th EAB would have, therefore, been in a "very serious predicament" had it not been for the efforts of an advance party of the 811th EAB to secure the minimum items needed to house and feed itself (116:1-2).

The 811th EAB spent the period from 3 to 13 December in Japan locating and acquiring, sometimes by "devious means", heavy equipment for its impending deployment to Korea (182:285). The 811th obtained all but its non-critical equipment before leaving for Korea on 14 September 1950 (182:285). Although the 811th EAB arrived at Inchon on 25 September 1950 without its full compliment of heavy equipment, the 811th EAB was more concerned about the tremendous difficulty it had in unloading what equipment it had over the beaches of Inchon (88:169).

The 811th EAB encountered additional problems unloading and handling the heavy and bulky PSP because the cranes had

been loaded so that they were unloaded last (117:2). Similar problems of incorrect loading of ships had been experienced during WWII.

Another experience common to both WWII and the Korean War was the theft of vehicle and equipment parts while in transport. Without guards to protect the equipment, thieves would literally strip equipment of all its essential parts (75:16). Frequently, the pilfering left the equipment in an unuseable condition and the stripped pieces of equipment would have to be salvaged (75:16; 118:no page).

The shortage of adequate clothing for the aviation engineers of WWII was also experienced during the Korean War. Documentation of this clothing shortage was found in most of the unit histories of the aviation engineers. The unit histories for "A" Company of the 808th EAB recorded the following in April 1952:

> The clothing situation remains critical concerning fatigues, in fact, from personal observation some of the men are beginning to show behind.

The unit historian also recorded that there were shortages in combat boots, socks, and summer underwear (115:2). One of the causes for these problems was not the lack of transportation, but the slow and inefficient supply procedure and process.

The 8th Army Engineer Supply was the approving authority for all requisitions of engineering construction supplies and materials (75:16). Once the 8th Engineer Supply approved the requisition, the supply request was

forwarded to the 2nd Logistical Command at Pusan, Korea (75:16-17). The 2nd Logistical Command would then issue the requested supply item, if available (75:12). Requests which could not be filled because of shortages, were returned to the requesting agency with a recommendation to obtain requested items by local purchases; or the unsatis-fied requests were forwarded by the 8th Army to the Japan Logistical Command (75:17).

This supply process was slow and many times ineffective. The 417th Engineer Aviation Brigade found that it often took three days to obtain items which were readily available when using "emergency requisition" procedures (231:181). The time between request and delivery using normal supply procedures was 30 to 40 days (231:181). Supply items which had to be ordered from the United States usually took 160 to 180 days (231:181). The 839th EAB noted these excessive delays in their June 1952 Historical Report that:

> "The time lag in filling requsitions is too frequently excessive due to the number of channels through which the requisition may pass and time required at each stop to process the requisition" (127:9).

One of the factors which caused delays was the different stock numbers used by the Army and Air Force to describe supply items. The SCARWAF units in the United States used the Air Force supply procedures and stock numbers (231:181). The SCARWAF units in the U.S. did not

deal with the Army in obtaining supplies, as all requisitions forwarded to the Army were handled by the base level supply agencies and not the SCARWAF units (231:181). When these SCARWAF EABs arrived in Korea they were required to interact with the Eighth Army Engineer Supply and, therefore, use Army requisition procedures and stock numbers (231:181). Too complicate matters, there were many changes in the supply procedures (231:181). Therefore, by the time the SCARWAF units became proficient at using one system they had to learn a new system. This constant change resulted in many delays.

Personnel Problems

As mentioned earlier, General Vandenberg described the USAF in 1950 as a "shoestring" Air Force (88:65). While many of the FEAF organizations lacked everything they needed for war, they were able to respond when the war began in June 1950 (88:58). This was not the case for the FEAF aviation engineer units (88:58). The total strength of the FEAF aviation engineer force included two Engineer Aviation Group Headquarters, five Engineer Aviation Battalions, and one Engineer Aviation Maintenance Company (81:1). While these units were manned to approximately 80 percent of their authorized productive strengths, they were manned to only 53.8 percent of their wartime authorization (assigned 2,332, authorized 4,315) at the onset of the Korean War. For example, "A" Company of the 802nd EAB, the first EAB deployed to Korea, required personnel and equipment reinforcements before it could

deploy to Korea (182:284-285; 116:4). On 14 July 1950, General Stratemeyer, Commanding General FEAF, while advising General Vandenberg of the Korean airfield status said:

> If we had aviation engineer units at nearly even full strength with proper SSNs as our Air Force units, the operations would have been initiated from both strips last Friday (7 July 1950).

Just prior to the Korean War (Spring 1950), the commanders of the 930th EAGs had noted the combat effectiveness of their aviation engineer units to be only 10 to 25 percent of what the EAB were during WWII (210:31-32). According to the FEAF, the overall combat readiness index for their aviation engineer units was approximately 35 percent (182:284).

The low combat readiness index indicated that the aviation engineer units were unable to respond effectively. One reason for aviation engineer manpower problems was the result of manpower cuts which had been directed on 11 and 19 May 1950. These manpower cuts affected all aviation engineer units, particularly the EABs. The EABs were reduced from 33 officers and 744 enlisted men to 27 officers and 587 enlisted men (116:3). The cut in manpower obviously affected the combat readiness of the aviation engineer units.

The problem of acquiring a sufficient number of aviation engineers with the right skills and job specialities continued throughout the Korean War. The Army's response to the Air Force's request for more aviation engineers was that the SCARWAF units were manned to the same levels as their

own units (182:7-8). On 15 July 1950, the USAF was, however, able to arrange the deployment of 870 replacements for the undermanned aviation engineer units in Korea (81:7-8). On 26 July 1950, the FEAF was forced by circumstances to request an additional 1,237 personnel. This time, the USAF had no luck in obtaining the Army's approval (182:19). Because of the urgency for airfield construction forces at that time, the FEAF recommended that airmen with the proper qualifications be used to fill the positions for which the Army could not provide personnel (182:19). The FEAF also recommended tha the training and control of the EABs be relinquished by the Army and given to the Air Force (182:19).

On 12 September 1950, the FEAF was authorized to reorganize its aviation engineer units so that the resulting units would have the manpower which was close to the authorized strength of an EAB (182:20). The FEAF aviation engineer units, even after reorganization, were not capable of meeting the airfield construction requirements. Therefore, on 6 March 1951, General Stratemeyer requested five additional engineer aviation battalions, three engineer maintenance companies, one petroleum distribution company, one engineer dump truck company, and two engineer supply platoons (230:91). The USAF advised General Stratemeyer that these units were not available and that all FEAF aviation engineer units should be committed to the Korean Theater (230:91). USAF further advised General Stratemeyer

to use private local contractors to complete on-going projects in the rear areas (230:91). This initiation was implemented but the five battalions in Korea were still not enough to handle the workload.

In November of 1951, some relief to the aviation engineer manpower problem was experienced as the Army reassigned 1,100 personnel from the Engineer Basic Training Center to the FEAF. While these personnel represented a substantial gain in rear manpower, they were not fully trained and had no practical experience (81:8). By the time these untrained individuals were adequately trained to operate the complicated heavy equipment, it was time for them to rotate back to the U.S. (230:96). Two more EABs were also assigned to the FEAF by November 1951, bringing the total strength to two Aviation Group Headquarters, two Engineer Maintenance Companies and seven Engineer Aviation Battalions (210:2).

As the war progressed, however, this aviation engineer force proved to be inadequate. In December 1951, the FEAF advised the USAF that five more EABs were needed in addition to the seven existing EABs in Kore (210:41). Finally in June 1952, two years after the Korean War had begun, the aviation engineer force was increased to ten EABs, three groups, two maintenance companies, a Topographic Detachment, and a Supply Point Company (210:5). The FEAF and 5th AF had originally thought that ten EABs would have been the minimum construction force which could satisfy Korean War airfield

construction. This estimate, however, did not include the construction effort needed to provide airfields in Northern Korea (177:5-6). Overall the ten EABs were considered to be adequate. The ten EABs resulted in a ratio of one construction battalion to one AF combat wing in Korea (231:182). Throughout the Korean War, efforts were made to supplement the inadquately manned aviation engineer forces in Korea.

As previously mentioned, General Stratemeyer acting on the recommendation of the USAF directed all troop construction forces involved in rear area construction to forward locations in Korea. For example, prior to April 1951, the Korean airfield program was being supervised and controlled by aviation engineers. These units were transferred when the airfield work was continued with private contractors (210:38). Contractors were also employed in the forward areas. On 13 July 1951, a contract was signed with the Vinnell Corporation to provide 39 techicians from the U.S., 14 technicians from Guam and Okinawa, 6 D-8 tractors and 2 D-12 graders (182:284). In some cases, Vinnell technicians would supplement the EABs by acting as equipment operators and mechanics (117:2). The Vinnell technicians were needed more desperately to instruct inexperienced aviation engineer troops on proper operation of heavy equipment and on construction techniques (75:2). The Vinnell technician had been retained to act basically as technical representatives and subforemen on construction projects (75:3). To insure the Vinnell technicians were being used properly, the 5th AF

Deputy of Installations assumed direct control of these technicians and published specific procedures for employment of the Vinnell personnel (75:3).

The FEAF received permission from the USAF in September 1952 to supplement SCARWAF EABs with Air Installation personnel. This initiative increased the SCARWAF manning levels to an "acceptable standard" (81:8). Local labor contractors were also needed in forward areas to supplement the EABs. General Partridge wrote, however, that the "efforts in the employment of contractors were not sufficiently productive . . ." (181:3). General Partridge also wrote that the aviation engineer effort at the beginning of the Korean War had been "inadequate" and that they were not as prepared as the other air Force units to respond to the Korean hostilities on 25 June 1950 (181:1). According to the FEAF:

> The lesson was evident that SCARWAF engineer units, upon which the Air Force must depend in time of emergency, should be assigned to Air Force for complete support in order that the using agency could take necessary steps to properly man, equip, and support these units (210:101).

Rotation Problems. One of the biggest personnel problems during the Korean War was the rotation policies. The year long tour of duty in Korea resulted in a constant change over in personnel. Two problems resulted from this rapid rotation policy. First, the flow of replacement personnel never matched the outward flow, reulting in a constant personnel shortage (231:179-180). Second, by the time

an aviation engineer had been properly trained, gained some practical experience and become accustomed to the environment, it was time for him to transfer back to the U.S. The commander of the 417th Engineer Aviation Brigade stated that "This deficiency was the major deterrent to satisfactory operations within the Engineer Aviation units" (231:180). The 802nd EAB recorded in their November 1957 unit history that experienced personnel were rotating back to the U.S. faster than replacements were being received (109:17). The 802nd noted that the loss of key non-commissioned officers and officers was a "threat to the unit and the mission" (109:17). The 839th EAB recorded in its April 1952 unit history that the "greatest problem to date" was the mass departures of personnel to the U.S. In many cases, experienced and qualified officers rotating out of Korea were replaced by officers who had just graduated from Officers Candidate School and the Reserve Officers Training Corps (81:10). These new officers generally had no working experience under field conditions (81:10). Lack of experienced and senior ranking officers and non-commissioned officers was a definite problem during the Korean War. For example, at one point during the Korean hostilities the 839th EAB was manned as follows (81:10):

Table III

839th Engineer Aviation Battalion Manpower
(Typical)

Grade	Authorized	Assigned
Lt Col	1	Ø
Major	2	2
Captain	8	2
1st Lt	26	4
2nd Lt	Ø	2Ø
Warrant Officer	8	4
E-7	23	3
E-6	48	7
E-5	216	27
E-4	352	141
E-3	269	494
E-2	54	195
E-1	Ø	12

The rapid rotation system caused the manpower of the FEAF aviation engineer units to alternate between having too few personnel to having too many personnel (most of whom were not properly trained). For example, in the late half of 1952, the 417th EAB was losing more men than it was gaining. However, on 28 December, an influx of basic trainees increased the manning to 11Ø percent of what was authorzed. The percentage of the officer strength was 75 percent of authorized strength and the non-commissioned strength was only 36 percent of authorized strength. In fact, by 31 December 1952, 65 percent of the 417th EAB's assigned officers were lieutenants (231:18Ø). The lack of experienced engineering officers and non-commissioned officers prompted 5th AF's Deputy of Installations to state:

> Too little and too many "eye ball engineering principles were used because the officers and non-coms had not been trained in aircraft characteristics, loads, basic requirements, importance of drainage, etc. (129:6).

Training. The rotation policy combined with the initial inadequate training of the SCARWAF to produce aviation engineer units with low combat readiness. The EABs in Korea combated this problem by establishing extensive on-the-job training (OJT) programs. While the EABs conducted OJT on almost every aspect of engineering construction, the primary emphasis was on the operation and maintenance of equipment (125:3). The EABs consta ly conducted OJT and to some degree the OJT programs helped to reduce the affects of the rapid rotation process (120:3; 125:1). The unit OJT program, as in WWII, degenerated in many cases to learn-by-doing (121:1; 114:5). This situation led to unnecessary vehicle abuse and costly mistakes in terms of money and time. The engineers contended that the OJT programs could not get at the "root of the problem."

As mentioned, the Aviation Engineer Force was established on 10 April 1951 and charged with the "mission of insuring the highest possible level of operational readiness for all aviation engineer units in the continental United States" (93:Background). To accomplish this mission the AEF took control of the SCARWAF units immediately after the units completed the Army training program. The AEF then provided formal training courses and assigned stateside SCARWAF units to peacetime-type construction projects in

order to improve and maintained the aviation engineer units (93:1). The AEF was able to assemble enough material and equipment to equip the 622nd Engineer Maintenance Company and the 809th Engineer Aviation Battalion prior to their deployment to Korea in September 1951. The 1903rd EAB was also prepared, equipped and deployed to Korea by the AEF for deployment to Korea in November 1951 (230:91). The AEF throughout the remainder of the Korean War was able to improve the operational capability of replacement aviation engineer units.

Morale and Health. Not only did the rotation policies adversely affect the manning and training efforts of the aviation engineer units, it also appears to have been the primary morale problem. Problems in morale occurred when rotation policies or rotation orders were changed and resulted in the cancellation or delay of personnel returning to the U.S. (88:103). "Misinterpretation" of the complicated and constantly evolving rotation policies also resulted in morale problems when personnel expecting an immediate return to the U.S. were informed that they were not eligible for rotation as soon as previously expected (112). Living conditions and the quality of rations also, as one would expect, was a major morale factor (110:4).

Living conditions were also major factors in the health of the aviation engineers, particularly during the winter months. Aviation engineers were often required to work in

extreme cold. The 811th EAB recorded the effects of cold weather combined with improper living conditions in its October 1950 unit history that:

> With the coming of colder weather there was a rise in respiratory diseases due to the combination of long working hours, improper clothing and poor (initially) living conditions (117:8).

Extreme cold was not the only health threat for the aviation engineer. The 839th EAB recorded in its April 1952 unit history that although the crab lice infestation experienced in March had subsided, preventive measures would be continued (126:9). The 839th EAB also recorded that chloriquine was being dispensed on a weekly basis to prevent malaria epidemics (126:9). The authors noted that a prevalent medical problem and concern recorded in almost every unit history reviewed was that of venereal disease (122:10; 117:8; 121:11; 112; 119:7). There were other sources of medical problems which proved to be as difficult to combat, such as the local Korean whiskey which members of the 808th EAB found extrmely hazardous (65:3).

Summary

Following WWII, the Air Force was established as a separate and independent military service. The Air Force, however, depended on the Special Category Army Units With Air Force (SCARWAF) for the construction and rehabilitation of airfields during contingencies and wars. Manpower authorizations and funds for these SCARWAF units were provided by the Air Force. The Army was responsible for

training, equipping, and controlling these SCARWAF units until they were needed for contingency or wartime construction of airfields.

The Air Force was opposed to this arrangement, because, it had no control over the quality and readiness of these SCARWAF units. There was one advantage of the SCARWAF system over the initial command and control of aviation engineers during WWII. That advantage was the absolute Air Force control of SCARWAF units once they were deployed to a theater of operations to support Air Force construction requirements. The Air Force argued, however, that because they (Air Force) depended so heavily upon the SCARWAF units, the selection, training, and complete control should be transferred to the Air Force. Using SCARWAF's poor record fo responsiveness and performance as justification, the Air Force was able to establish the Aviation Engineer Force (AEF) on 10 April 1951. The AEF was charged with improving and maintaining the readiness of SCARWAF units following their initial training by the Army. The AEF also controlled the assignment of SCARWAF units following the initial Army training. The Air Force, therefore, had control of these SCARWAF unit except for the essential selection and initial training phase.

The Air Force also enjoyed the control of its own airfield maintenance organization, the Air Installations Squadrons, during the Korean War. While the Air Installations Squadrons were organized and equipped for repair and

maintenance work, they often had to perform new construction and major rehabilitation. Another improvement in the command and control of aviation engineers occurred when the Directorate of Installations, 5th AF was removed from its subordinate staff position under the Deputy of Material and placed directly on the 5th AF General Staff as the Deputy of Installations. This organizational structure allowed the Deputy of Installations to insure that the capabilities and requirements of the aviation engineers were given adequate consideration.

While improvements were made in command and control, the aviation engineers experienced, as they did in WWII, problems related to inadequate drainage and soil preparation. Failure to provide adequate drainage and stable bases for runway surfaces was the major cause of runway surface failures. The lack of proper drainage and soil preparation was generally the result of inexperienced personnel and the initial construction standards endorsed by 5th AF. All construction during the early phases of the Korean War was based on the six-month life expectancy. As the Korean War continued into the year 1951, airfield surfaces and facilities constructed on a six month life basis been to deteriorate. The result of this deterioration was excessive damage to aircraft, delays in operational missions, and the requirement for expensive rehabilitation. The six-month life expectancy construction policy was recognized by the

5th AF Commander as being wasteful, and directed the aviation engineers in May 1951 to "Build the best establishment you can and assume you will be staying there" (88:363). The construction standards were then changed to be based on a two year life expectancy.

The 5th AF Deputy of Installations recognized the need for a construction policy that would specify the standards of construction for specific missions, aircraft, and tactical plans. On 25 September 1951, one year and two months after the Korean hostilities began, an official construction policy was published. This construction policy facilitated effective construction programs and planning. While the construction policy needed to be standard, it was also recognized that it must also be flexible to permit effective base master planning. Experiences during Korea indicated that master plans should be developed by the Headquarters Staff as the base level personnel only to recognize the immediate requirements. It was recognized that effective master plans were needed to allow for mission changes and for expansions/upgrades required for the increasing support requirements demanded by the modern aircraft. Just as the introduction of the B-29 during WWII necessitated longer and stronger runways, the jet aircraft and the heavier cargo aircraft introduced during Korea resulted in runway expansions and upgrades. The 4,000 foot runways of WWII no longer suffered and typical runway lengths of 9,000 feet or longer became the standard for Korea.

The low capability of the aviation engineers to construct adequate runways during the early stages of the Korean War was partially due to the lack of adequate equipment. Most of the available equipment at the beginning of the Korean War was of WWII vintage. The combinations of equipment age, rugged operating conditions, and inexperienced operators and maintenance personnel resulted in excessive construction delays due to "deadline" equipment. The introduction of new equipment in 1952 helped to alleviate some of the equipment shortages. The new equipment, however, increased training requirements for the operators and maintenance personnel and created a tremendous logistical support problem as spare parts for both old and new equipment were needed.

The lack of equipment standardization as well as standardized construction items such as POL facility components caused many problems for the aviation engineers during Korea. According to the FEAF's analysis of the Korean War:

> Airfield construction in Korea has been a costly operation and if we were to settle on the recommendation to simplify the problem we could sum it up in one word -- "standardize" (83:17).

Standardization would have reduced the amount of logistical support and in many cases simplified operation and maintenance of equipment.

Not only was the equipment in bad shape at the beginning of the Korean War, but so was the proficiency and manning of the available SCARWAF units. The Army was unable

to supply enough trained SCARWAF personnel. Unit on-the-job training (OJT) helped to improve the capabilities of the aviation engineer personnel to some degree. However, the rapid rotation of personnel resulted in personnel returning back to the U.S. just about the item they had learned their jobs and were becoming productive. The quality of incoming personnel was improved during the latter stages of the Korean War due to the efforts of the EAF. As mentioned earlier, the AEF became responsible in April 1951 for improving and maintaining the readiness of SCARWAF units.

As the Korean War ended, the Air Force had achieved a somewhat higher degree of control over their designated troop construction force. The AEF could insure that the SCARWAF units were prepared and ready to support Air Force construction requirements and the Air Force had control of the SCARWAF units in the theater of operations.

V. Post Korea Era (1954-1961)

As the Korean War ended, the Air Force had what was considered a somewhat reliable troop construction capability. The SCARWAF units were manned with approximately 35,000 aviation engineers at the end of the Korean War (67:11). The Aviation Engineer Force (AEF) had been able to establish a sound readiness program to insure that both the active duty and reserve SCARWAF units were capable of responding quickly to Air Force construction requirements (93). Major General Lee B. Washbourne, the Director of Installations, USAF, in October 1953 inferred that, without the AEF the SCARWAF system would be unreliable. He stated:

> The professional status of the force is protected and built up because only the Aviation Engineer Force can provide to the Air Force a dependable resource for the construction of base facilities during hostilities when civilian contractors must withdraw or don uniforms to constitute new units of the Force. Under Air Force auspices, there will be high interchangeability between personnel of the aviation engineer battalions and the installations squadrons so that their allied duties in the construction, defense, and maintenance of air bases will provide a combined reservoir of squadron and battalion officers and NCOs to support heavy but decreasing overseas rotations of individuals (22:33).

There was a major initiative undertaken by the Director of Installations and the Secretary of the Air Force in September 1953 to establish a total Air Force troop construction capability. On 26 June 1953, the Air Force sent a proposal to the Secretary of the Army for the transfer of the total responsibility of the aviation engineer units from

the Army to the Air Force (23:13). The Secretary of the Army concurred with the proposal on 16 January 1954 (23:13). This proposal was then forwarded to the Secretary of Defense on 9 February 1954. The proposed transfer of the aviation engineers, however, was not favorably looked upon by some such as Senator Byrd, who felt that the "agreement leaned away from closer unification without any material benefit" (23:13).

The sentiments for unification were based on trying to reduce duplication and, thereby, decrease military forces and spending. As previously mentioned, there is always a tendency to reduce military forces and expenditures following a war. Therefore, on 1 July 1954, the proposed transfer date of SCARWAF functions from the Army to the Air Force "passed without any evidence that Department of Defense approval of the agreement was in any way imminent" (67:187). On 3 July 1954, the Army-Navy-Air Force Journal described the delay as follows:

> POCKET VETO apparently is being used by SecDef Wilson in the matter of transferring SCARWAF personnel (about 35,000) from the Army to the Air Force. Months ago, the proposal, which had been agreed to by the Army and Air Force Secretaries, was slated for quick implementation.
>
> THE UNEXPECTED DELAY results apparently from Defense Dept. fears that the separation could result in extra costs and duplication of activities. Meantime, however, Mr. Wilson has not indicated that he is for the plan or against it.
>
> (67:187)

In the meantime, the Air Force experienced continuing problems with the existing SCARWAF system. Colonel C. B. Elliott, the AEF commander, stated that the SCARWAF deficiencies were the result of:

> 1. An annual turnover of SCARWAF personnel equal to AEF's authorized strength.
>
> 2. TO&E cuts, manning shortages (particularly in the middle officer and enlisted grades), inadequate input of well qualified or properly trained specialists, lack of realistic spare parts supply levels and trained parts personnel for sustained machine operations.
>
> (67:192)

Colonel Elliott also added that "full operational effectiveness" and sufficient operational equipment has never been realized by the aviation engineers when involved in continuous construction operations (67:190).

Although the AEF could conduct on-the-job training, it could not duplicate formal Army training courses and was not authorized to send new SCARWAF personnel to the Army training courses (67:190). The Air Force, therefore, continued efforts to obtain its own construction force.

The Army, however, created a potential roadblock to the realization of an autonomous Air Force troop construction force. After initially concurring with the Air Force proposal on 16 January 1954, the Army reversed its position in 1955 and recommended that all aviation engineer functions be returned to the Army (24:8). The Secretary of Defense was convinced that the Army could support both its own requirements and the Air Force's construction requirements.

The rational behind this decision was that the Air Force's war time construction requirements were initially very high, while the Army's needs were negligible at the onset of war (22:34). As the war would progress, the Army engineers would be able to focus their efforts on construction required to support ground operations. In line with this concept, the Secretary of Defense, on 2 December 1955, directed that the SCARWAF system be dissolved by 1 March 1956 (93:ii). Thus, the Air Force not only lost any hope of obtaining its own wartime construction force, it lost what control it had over the Army supplied SCARWAF units.

The responsibilities for airfield construction, repair, and maintenance were clearly defined in the Department of Defense (DoD) Directive 1315.6. According to this DoD Directive which was published in 1957:

> A. The Department of the Army is responsible for providing military troop construction support to the Air Force overseas, including:
>
> 1. Organizing, manning, training, equipping, maintaining, directing, and controlling all units and personnel, including those of the reserve components, required to provide this support.
>
> 2. Budgeting and funding for the required units.
>
> B. The Department of the Air Force is responsible for developing and maintaining a capability for the emergency repair of bomb damaged airbases within the organic capability of air installations resources. A limited number of specialists may be provided . . . to supervise development of this capability.
>
> (195:1-2)

While the Air Force was given no formal construction responsibility or capability, it was given the responsibility and resources needed for bomb damage repair. This organic repair capability would prove to be a significant factor in the upcoming 1958 Lebanon Crisis, the 1961 Berlin Crisis, and the Vietnam Confli t.

Lebanon Crisis (1958)

President Eisenhower, on 15 July 1958, deployed 5,000 Marines to Lebanon in order to stabilize the political situation (22:35). In order to support these ground forces, the Air Force was directed to provide a staging base at Adana, Turkey (79:36).

Prior to the Lebanon Crisis, the existing facilities and utilities were barely enough to support the small permanent party assigned to Adana (147:6). The Adana airfield already suffered from an inadequate water supply and POL and generator problems (147:3). To complicate matters, there were no construction forces at Adana. In fact, the maintenance contractor had only begun working at Adana 15 days prior to the massive and rapid build-up.

While the contractor eventually mobilized additional employees, to meet the demand for 24 hour per day operation and maintenance, there were some serious problems encountered with the original contractual agreements. The original maintenance contract was based on peacetime operational and maintenance requirements. As such, the contract

specified that the contractor was responsible for a certain predicted volume of work. There were no provisions in the original contract for contingency operations and maintenance activities (147:6-7). Immediate problems were encountered during negotiations to expand the original scope of the contract.

Establishing an adequate maintenance force was not the only problem encountered during the Lebanon crisis. As previously mentioned, the Adana airfield had an inadequate water supply and a new four inch water supply line was desperately needed. The installation of this water line was considered to be construction-type work. Therefore, in accordance with DoD Directive 1315.6, the Army was requested to provide the needed construction forces for the installation of the water supply line. Army assistance for this water line construction was obtained only after "extreme measures" were taken to secure a company of Army engineers that was just about to return to the States (147:6). The shortages of electrical power and facilities also necessitated the rapid acquisition of generators and erection of tents to support the massive influx of thousands of transient troops and tons of supplies. The airfield surfaces also required major repair and extensive maintenance because the continuous flow of heavy aircraft caused rapid deterioration of the airfield pavements (147:6).

Total dependence on contractual maintenance forces and Army construction units had proven to be unsatisfactory

during the Lebanon Crisis. The United States Air Forces in Europe (USAFE) recognized the need for a greater capability to rapidly respond to such contingencies as the Lebanon Crisis (147:7). USAFE's Directorate of Civil Engineering conducted a survey to determine the operations and maintenance (O&M) capabilities of all USAFE bases. Using this survey and the past experiences of the Lebanon Crisis, USAFE developed two initiatives. One initiative was to obtain support agreements (in terms of maintenance and construction of airfields) with the NATO (North Atlantic Treaty Organization) host nations. The second initiative was to create an engineering force which could rapidly respond to support contingency Air Force operations. This initiative led to the development of the Civil Engineer Mobile Team Concept (147:7).

This concept called for certain Civil Engineer (CE) personnel within USAFE to be designated as CE Mobile Team members. Members of the CE Mobile Team were responsible for insuring that, they and their equipment were ready to respond within 24 hours. The CE Mobile Team Concept did not specify a particular size team. The size of the mobile teams was determined by the contingency requirements (147:7). The following is an outline of USAFE's Civil Engineer Mobile Team Concept:

1. Team composition would be limited in size. (Airmen comprising the team would have to come from available USAFE personnel resources).

2. The team would be composed of detachable cells capable of providing limited emergency operation and maintenance services at forward operating bases.

3. The entire team would function only in support of essential operation and maintenance.

4. The team would not have a construction capability. (The Army would provide needed construction services).

5. The team would have to be highly mobile and fast reacting.

6. Finally, the team would normally augment a Civil Engineer force in being. In the event of withdrawal of a civilian work force, the team would require a capability to provide the most essential utilities and facilities operation until augmented by a military personnel build-up.

(147:7)

While developing the concept for the CE Mobile Team was not difficult, determining how the teams would actually be manned became a difficult question. It was a foregone conclusion that the manpower for the CE Mobile Teams would have to come from existing USAFE manpower resources. This meant that many bases would experience reductions in their already critical CE manpower forces. It was not considered efficient for the USAFE bases to permanently sacrifice critical personnel to CE Mobile Teams which were deployed on an infrequent basis. The final solution was to assign selective personnel to the CE Mobile Teams by orders only. This system of manning the CE Mobile Teams allowed the USAFE bases to maintain the use of CE Mobile Team members for normal base maintenance and repair activities, while

simultaneously providing a pre-designated team which could be assembled within 24 hours t support contingency operations (147:7).

These mobile teams provided USAFE with the capability to rapidly respond to contingency situations such as the Lebanon Crisis to operate and maintain airfields in any world-wide location. The CE Mobile Teams provided the most effective and efficient use of the organic repair and maintenance forces authorized by DoD Directive 1315.6. The CE Mobile Team Concept would prove to be the forerunner of the Prime Base Emergency Engineering Force (Prime BEEF) which would evolve during the Vietnam conflict. The CE Mobile Teams proved to be an effective and essential engineering force during the 1961 Berlin Crisis.

Berlin Crisis (1961)

On 25 July 1961, President Kennedy directed a build-up of all U.S. services in Europe in response to increased tensions in Berlin (187:2). The USAFE Staff was tasked by USAF on 16 August 1961 to determine the facility requirements needed for a massive military build-up. It was estimated that extensive mission increases and changes could possibly result in a 1,200 percent increase in USAFE facility requirements (187:2). The existence of a strong and capable Facility Programs Panel allowed USAFE to determine all facility requirements necessary to support the proposed build-up of military forces in Europe. USAFE was also able to establish a firm construction plan which was

only changed to meet operational necessities. This firm construction plan reduced the "musical chair" exercises of constantly readjusting construction priorities. Finally, USAFE's authority to approve and fund projects was increased substantially (187:2).

In the midst of developing the plans and programs for the massive military build-up, USAFE was notified on Labor Day that the initial forces of the planned military build-up would arrive in Europe on the following morning (187:2). USAFE was able to handle this rapid and unexpected deployment by employing their CE Mobile Teams. These Mobile Teams prepared deactivated facilities which were needed to support the first arrivals. The CE Mobile Teams proved to be effective and essential in the preparation and maintenance of base facilities. Without these teams, USAFE would have been hard pressed to adequately support the rapid build-up in Europe as Army support was very limited. In describing the Army's support of USAFE's build-up in Europe, Brigadier General Oran D. Price, the Director of Civil Engineering, USAFE, wrote:

> Support by Army Engineer troops was something less than satisfactory. Shortly after this emergency began only one Army Engineer battalion could be assigned to support the Air Force. This unit, a regular construction battalion, was neither trained nor equipped for airfield work. After the assignment of specifics tasks six weeks passed before the battalion had an effective work force operating, and then under a situation in which the Air Force furnished housing, messing, all of the supplies, and some of the engineer equipment (187:4).

The Army's response and support of the Lebanon Crisis of 1958 and then in the Berlin Crisis of 1961, as indicated above, was considered by the Air Force to be inadequate. As far as the Air Force was concerned, the Army had failed to fulfill its responsibilities as prescribed in the DoD Directive 1315.6.

While problems had been experienced with Army support, the USAFE Civil Engineers had been able to avoid some of the pitfalls previously experienced by aviation engineers. For example, USAFE had conducted standardization studies which resulted in the procurement of only four different size generators and two different size steel frame buildings (187:3). The use of standard pre-engineered steel-frame buildings allowed construction to begin before mission plans had been finalized. Changes were easily made by adding extensions as dictated by mission requirements (187:4). As mentioned earlier, the development of a firm construction plan for the construction of facilities had also improved the effectiveness and timeliness of the construction program (187:5).

Probably the most "favorable element was the understanding" that the USAFE Staff had of engineer requirements and capabilities within USAFE. This "understanding" was the result of a strong and active Facility Programs Panel (187:5). The members of the Panel had been kept abreast of the status of all USAFE facilities and pending facility requirements well in advance of the Berlin Crisis. Therefore, when

the "whistle blew" the members of the Facility Programs Panel were already aware of the shortcomings and capabilities of USAFE to provide facility support for the build-up (187:5).

Unfortunately, while the Facility Program Panels' members were kept informed of the facility requirements, the host NATO countries were not given advance notice of the need for additional facilities. For nearly two months, the Top Secret classification of information pertaining to the military build-up in Europe precluded the USAFE engineers to from including its host nation counterparts in the critical planning phase for the build-up. The security restrictions caused a two month delay before host nations and contractual support could be obtained to assist with the planning and construction. General Price described his frustration of working with this system when he wrote:

> If you want to accumulate gray hair in a hurry, try building facilities on a crash basis on an airfield owned by one foreign country and operate by another without being able to tell either element what is going on (187:5).

USAFE had been able to successfully support the military build-up in Europe primarily with contractors and its CE Mobile Teams. General Price warned, however, that the massive build-up in USAFE had been facilitated by the excellent condition of the standby bases, the availability of proficient construction contractors, and the ample supply of locally available skilled laborers in Europe(187:5). General Price concluded that: "It is sobering to USAFE

Civil Engineers to contemplate what the results could have been in less favorable circumstances" (187:5). General Price's warning appears today to have been a very uncanny insight into the future. For the next massive deployment of military forces was to Southeast Asia, where standby bases were inadequate or nonexistent, and capable construction contractors and skilled laborers were not readily available.

VI. Vietnam Era (1962-1975)

Introduction

This next area, the Vietnam conflict, is the time frame where AFCE achieved its greatest successes toward improving the performance of its contingency roles and responsibilities. Many of the historical problem areas already presented were still present going into the conflict and would remain throughout our involvement in Vietnam; but, major advancements were made in organizing and establishing deployable AFCE forces and in establishing an Air Force troop construction capability. During the Vietnam conflict, the Air Force also demonstrated an ability to be its own construction agent.

The discussion of the Vietnam conflict is divided into the following topical areas. First, a brief history of how the United States became involved in Vietnam and how the involvement escalated is presented along with the military command structure which evolved during the conflict. Second, typical Base Civil Engineer responsibilities and problem areas are covered. Many of the problems led to the development of Prime BEEF (Base Emergency Engineer Force) and this area is presented third. Next, the many problems associated with the construction of air bases in Vietnam are discussed. This area, Air Base construction, is subdivided into several sections. The first section explains the

programming, funding, contracting requirements, design, and construction materials used in Vietnam; the second section discusses the development of the Air Force's troop construction capability (RED HORSE); and the final section describes the turnkey construction of the base at Tuy Hoa, which demonstrated the Air Force's capability to accomplish its own construction. As U.S. involvement in Vietnam began to decrease, the AFCE's job became easier in Vietnam.

History of U.S. Involvement in Vietnam

After WWII and during the Korean war, the United States, China, and the Soviet Union emerged as the major forces for future world development. Many regions of the globe were viewed as colonies by our freeworld allies and as potential expansion areas by the communist factions. Vietnam and all of Southeast Asia (SEA) was such a region.

Our French allies had invested heavily in Vietnam and were not willing to relinquish their investment to the North Vietnamese factions who wanted to unite, and regain control, of their country. President Roosevelt had firmly opposed the French return to SEA, and had proposed instead an internationally supervised trusteeship to monitor the region (180:3). However, Roosevelt's proposal did not survive his death. The JCS, in 1954, also opposed any military involvement in Vietnam and described it as hopeless to expend U.S. military aid when an effective government, which was capable of raising and maintaining armed forces, was lacking in the

region (180:6). In spite of this opposition, President Eisenhower, in December of 1954, concluded the preparation of a formal agreement, South East Asia Treaty Organization (SEATO), between the United States, France, and South Vietnam and which was later expanded to include Laos, Cambodia, and Thailand, who would be provided direct U.S. military assistance (220).

SEATO initially provided for the development of the South Vietnamese army to resist external attack (Palmer:6). While many dollars soon began to flow into South Vietnam, U.S. military strength in the region averaged only about 650 advisors from 1954 to 1960 (106:14). As the North Vietnamese became more sure of themselves and received more and better equipment from their communist allies, the French recognized the futility of their efforts to maintain control in the region. By April of 1956, the French had completely with-drawn from the region (180:7).

Prior to 1964, U.S. participation was mainly through the Military Assistance Program (MAP), and Aid in Kind (AIK) program, providing military advisors, technical guidance, and facilities to aid the host countries (211:2). In 1962, President Kennedy, on the recommendation of the Army Chief of Staff, General Maxwell D. Taylor, directed a major expansion of the U.S. military advisory effort in SEA (180:10). President Kennedy also established, in February 1962, the United States Military Assistance Command, Vietnam (MACV) (180:11). The command structure involving MACV evolved

through 1964 and remained essentially the same throughout the conflict. Figure 1 shows the relationship of the USAF under this arrangement (180:32; 190; 38:4).

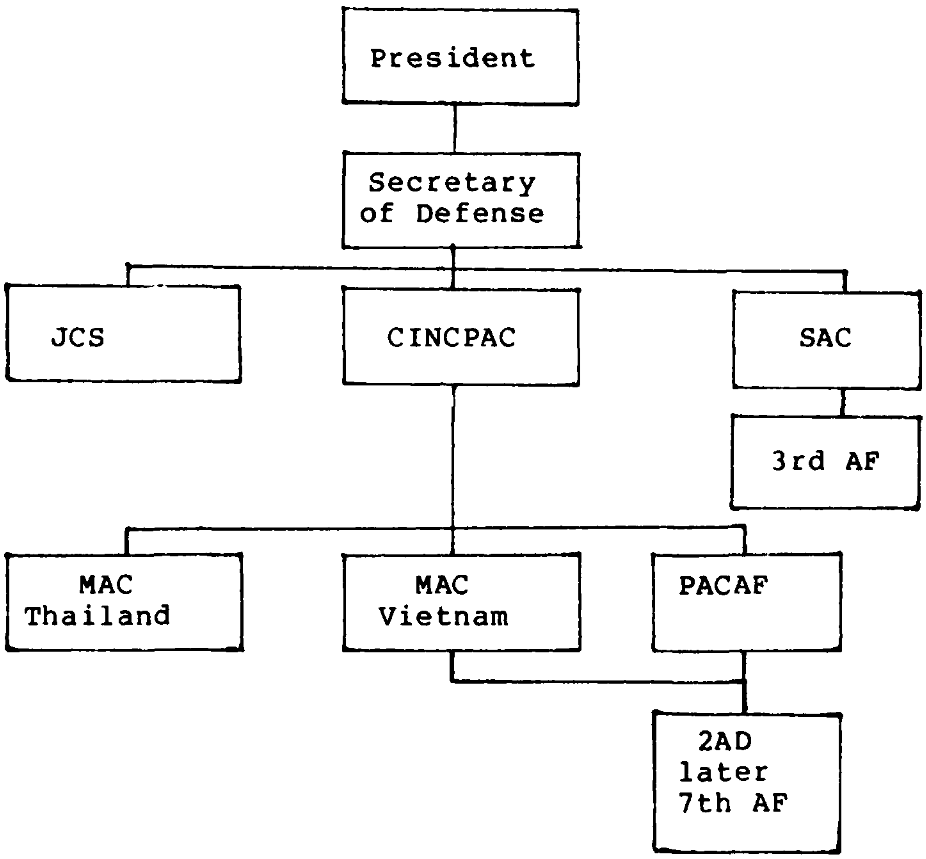

Figure 1. Command Structure

(JCS)-Joint Chiefs of Staff
(CINCPAC)-Commander in Chief, Pacific
(SAC)-Strategic Air Command
(PACAF)-Pacific Air Forces
(2AD)-2nd Air Division

MACV was subordinate to CINCPAC with the CINC Far East still being the unified command in charge of the Korean region (180:29), and the 7AF was subordinate to MACV (180:32). Increased U.S. military contingency actions in 1964 provoked

the Tonkin Gulf incident (220; 211) and the political and military situation in Vietnam worsened. On Valentine's day, 1965, all U.S. military dependents in Vietnam were ordered home (180:36).

In March 1965, President Johnson signed a bill which authorized commitment of ground forces, without mobilization of reserves, in Vietnam (220). A steady build-up of U.S. forces, including airpower, was soon underway which peaked in 1969 and began to decrease later that same year. Table IV shows the build-up from 1960 through 1969 and also demonstrates that U.S. military personnel strength in Vietnam peaked at greater than 540,000 in 1969 (106:14):

TABLE IV

Personnel Levels

Month/ Year	Total U.S. Military Personnel
Dec/ 1960	900
Dec/ 1962	11,300
Dec/ 1964	23,300
Dec/ 1965	184,300
Dec/ 1966	485,300
Dec/ 1967	485,600
Dec/ 1968	536,100
Jan/ 1969	542,400
Dec/ 1969	474,400
Dec/ 1970	335,800
Jun/ 1971	250,900
Aug/ 1972	40,000

From 1969 to the evacuation in 1975, U.S. military involvement continued to decrease. In August 1972 the last combat troops were withdrawn, leaving 40,000 American support personnel (180:121). Full scale evacuation began 20

April 1975 and by 30 April the last Americans, other selected foreign nationals, and thousands of South Vietnamese departed for good (180:150).

AFCE manning and responsibilities, although somewhat lagging behind some other U.S. forces in Vietnam, increased dramatically and the next several sections of this report deal specifically with AFCE in Vietnam.

Base Civil Engineering in Vietnam

This section deals primarily with typical operation and maintenance (O&M) responsibilities and problem areas which BCEs in Vietnam faced on a daily basis. The problems encountered in the O&M area stemmed from two sources: (1)the lack of established organization and manning documents which properly considered such factors as base population, numbers and types of aircraft assigned, numbers and types of facilities existing, and the physical and geographic characteristics of the base itself; and (2) an inadequate supply system (158). The following discussion focuses on these two major O&M problem areas.

Manning and Personnel. Generally speaking, the primary responsibilities of BCEs in Vietnam were to provide new facilities required by USAF units, to operate and maintain installation utility systems, to maintain facilities used by USAF activities, and to provide base fire protection (78:2). Most BCEs in Vietnam had these common functional areas which differed only in size and complexity. Figure 2 shows a common organizational chart (78:atch#1).

There were seventeen locations in Vietnam which had a BCE organization. These organizations, prior to the build-up, were small detachments or squads (190:112). As the build-up accelerated, BCEs were faced with an enormous job, rehabilitating many old French and Japanese airfields (227: 3). In addition, concurrent with the construction of a base, an operational mission was assigned which required a nucleus of a Civil Engineer organization, further taxing the BCE staffs (158).

The small contingents at each base were grossly under-manned and additional personnel always lagged behind the increases in duties associated with the build-up. For instance, in 1962, AFCE personnel strength for the whole 2nd Air Division numbered 128 persons and 7 officers, but, by July of 1963 there were over 1400 people and 14 officers (244:2). Additional personnel were still required and BCE forces were augmented with PACAF temporary duty (TDY) and continental U.S. (CONUS) TDY personnel (190:13).

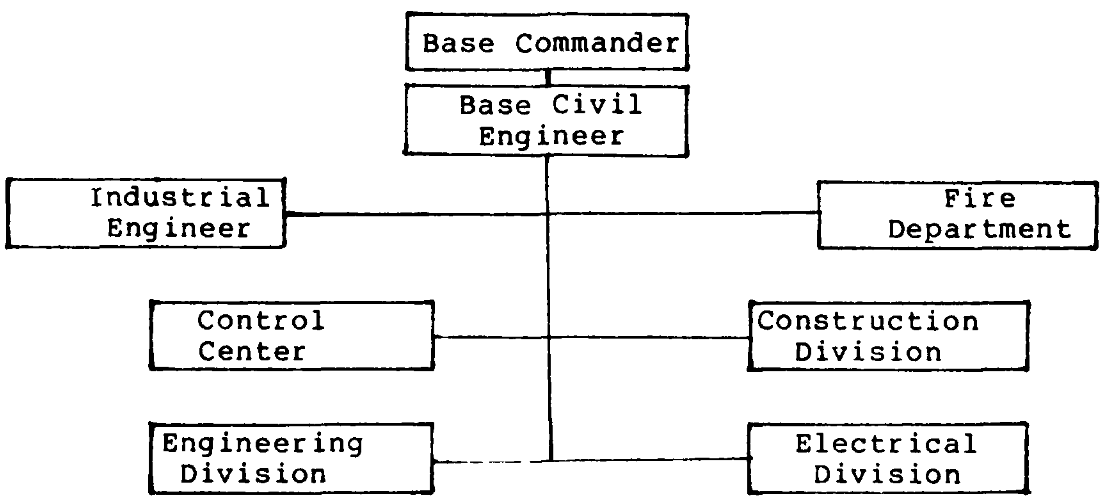

Figure 2. BCE Organizational Chart

BCEs also faced other manning and personnel problems besides shortages: (1) unskilled and untrained craftsmen; (2) the lack of a supervisory capability; and (3) the problems of dealing with the local national part of their workforce, which greatly outnumbered the U.S. military personnel at most installations. Each of these problems will be discussed in greater detail.

A major problem of the BCEs was the low proficiency level of personnel. In his end-of-tour report, Capt Benigno Soto, the OIC Maintenance and Repair Division, 377th CES, Tan Son Nhut Air Base, from 1 July 1966 to 10 May 1967, presented a representative classification of the types of personnel assigned to Vietnam. He classified the first group of individuals as those with experience in maintenance, repair, and construction by virtue of having been previously assigned to overseas areas where the bulk of the work was not accomplished by Civil Service tradesman. This group could achieve full capability almost immediately upon arrival; but, they also represented the smallest percentage of the total workforce and were made available primarily through the Prime BEEF and RED HORSE programs. These programs are discussed in greater detail later in this report.

The second group represented those persons who had no experience working alone because of their previous subordination to civilian tradesman. This group was trained to repair by replacement and was not able to repair with the

typically unconventional materials available in Vietnam. This group typically required 60 to 90 days to achieve full capability.

The third group included those individuals with civil engineering AFSCs who had spent most of their careers not in AFCE but in associated jobs such as supervising hobby shops or as aircraft sheet metal workers. This last group required 120 days to achieve full capability, if they ever did achieve it. (208:1-3)

Given the 365 day tour length in Vietnam and the relatively long lead time to achieve full capability for the bulk of the work force, BCEs were constantly faced with only a partially capable workforce (58). The twelve month tour in Vietnam was too short to maximize the effectiveness of engineering personnel (34).

There was also a critical shortage of experienced supervisors. During previous assignments at USAF bases, military personnel frequently worked under civilian supervisors and were given little responsibility for the work they performed. The situation in Vietnam was dramatically different. Newly assigned personnel were suddenly put in charge of shops or workcrews of 30 or more men who were mainly unskilled local nationals, unfamiliar with the methods which the new supervisor was accustomed to using (102:3; 78:3). This increased the problems of the inexperienced

supervisors overseeing the efforts of inexperienced USAF personnel and well-meaning but inadequately prepared local craftsmen.

There were several problems the BCEs encountered with the local national part of their workforce. Typically, local nationals comprised a large portion of the workforce as was indicated by the example that in December 1965 the local national employees of the 6250th CSG outnumbered USAF military engineers nearly four to one (78:2). U.S. O&M methods were unfamiliar to the local nationals and this problem was compounded by the face-saving insistence of the local nationals that "yes, yes, we know" and the general inability of AFCE NCOs and officers to communicate adequately to correct the problem when the local nationals used their own techniques (102:4).

The final problem concerning local nationals concerns the availability of skilled craftsmen. Skilled, local national craftsmen were difficult to recruit because of the severe manpower shortage created by the South Vietnamese draft, the higher wages paid by the Navy's cost plus fixed fee (CPFF) contractor, and Vietnamese Air Force (VNAF) security restrictions made it difficult for persons not having relatives in the VNAF to obtain the necessary clearances. When local nationals were recruited, they would often use the USAF job to acquire the necessary training and

job experience, then leave for the more attractive salaries with local contractors . Local national turnover throughout the Vietnam conflict was very high.

Day-to-Day Operations. The personnel and manning problems were only a part of what BCEs in Vietnam had to contend with on a daily basis. The extreme heat, six month hot-wet and hot-dry seasons, and the rough terrain throughout much of Vietnam continuously presented problems (227:3). In fact, in nearly every facet of day-to-day operations, BCEs were faced with problems not encountered in CONUS assignments. The most troublesome problems were: (1) the lack of, or inadequate, supply of materials and the poor quality of these materials when received; (2) the problem of supplying, distributing, and maintaining power distribution systems; (3) and potable water supply and sanitation problems. There were many other problems associated with the construction of facilities and they are detailed in a later section.

Civil engineering was by no means the only organization in Vietnam with supply problems. The logistics system in Vietnam was principally a "push" system which sent in tons of unrequisitioned material, much of which could not be readily used but had to be handled by an already undermanned supply force (158:2; 220). The manning of the supply force was based on CONUS standards where many items were acquired through local purchase and did not have to be stocked or handled (158). As far as AFCE requirements were concerned,

there were generators, water supply materials, runway matting, revetment material, and a multitude of other items which had not been required in the CONUS but which were required in Vietnam and had to be received, stocked, and accounted for (158). Neither the system nor the people were ready for this and conditions improved only slightly.

To further complicate matters, the supply system had been designed to handle materials with automated equipment which was not readily available in Vietnam. This problem caused many ships, arriving at the limited ports in Vietnam, to wait sometimes for weeks to be off loaded (58). Even when the materials were off the ships, they could not be moved out to the field units because of the limited transportation network. Large stocks of engineering supplies accumulated on the coast of Vietnam but could not be transported to the organizations which needed them (158:3; 78:8). As a result, BCEs were forced to acquire some materials such as lumber and pipe locally.

Lumber, which came from primarily local, Malaysian, or Singporean origin, was principally mahogany, which was green and dense. It was hard to nail, saw, and work. Ripping this lumber into structural size sections usually entailed burning several sawblades before the required amounts were cut (208:2). However, this lumber was resistant to infestation by the various beetles and termites common locally. Lumber shipped from the states was usually contaminated at the docks long before it was ever used (208:3).

Considerable pipe and associated plumbing parts were purchased locally. This pipe was primarily of French origin, and had much thinner walls and was not as durable as standard U.S. pipe. In addition, the pressures, which our U.S. systems were designed for and which we were accustomed to, caused frequent failures in the French piping (102; 224:5).

Another major, daily BCE problem was associated with the supply, distribution, and maintenance of electrical power and the distribution systems. Jerome Peppers, retired USAF maintenance officer and former Associate Dean of the School of Systems and Logistics at AFIT, has referred to the Vietnam conflict as "the first air-conditioned war" (184). BCEs were responsible for insuring that air-conditioning systems, as well as all other base electrical systems, were adequately supplied with electrical power. Local commercial sources were not able to supply the tremendous power requirements. Even if they had the capacity, the local 50 cycle power was not compatible with U.S. 60 cycle equipment (227:6; 211:46; 244:2). As a result, BCEs often had fully equipped shops but much of the equipment was useless without adequate electrical power (102).

The U.S. military generators used in Vietnam were old, diesel driven models, and subject to frequent failure (227:6; 149:3; 190:113). In addition, the generators were not designed for continuous operation. This caused another

maintenance burden to keep them operational. Once generators arrived in country and experienced failures, repair was extremely slow. The following quote by the 2nd Air Division Director of Civil Engineering in 1964 illustrates this problem :

> ...a specific example is the 200KW Cummins Diesel generator at Tan Son Nhut. The unit was received in a damaged condition in March 1964. The replacement parts have been on order and re-order and at the end of 1964 were still not on hand...[211:5]

There were some 50 different makes and models of generators used in Vietnam. Parts were not interchangeable and large stocks of similar yet incompatible spares had to be maintained. An optimal condition would have been to have had no more than 6 to 8 types. This would have provided the necessary competition in the procurement of generators but could have significantly reduced the maintenance manhours and downtime required to keep them running (158). Although generator requirements were identified and forecasted by PACAF generator procurement continued to lag the build-up (211).

Power plant construction was initiated in 1964 but construction always lagged behind the force build-up (190:113). Table V shows the power plants which were approved for construction in SEA as of August of 1964 (211:52).

TABLE V

Approved Power Plants

Base	No. of Generators	BOD	Program
Tan Son Nhut(RVN)	3-500kw	Sep 65	FY64 EMCP
Bien Hoa (RVN)	5-200kw	Aug 65	FY64 EMCP
DaNang (RVN)	5-200kw	Sep 65	FY64 EMCP
Nha Trang (RVN)	3-200kw	Oct 65	MAP
Don Muang (RTG)	3-200kw	Aug 65	FY64 EMCP
Ubon (RTG)	4-200kw	Jun 65	FY64 EMCP
Udorn (RTG)	4-200kw	May 65	P-341

The ever changing conditions in Vietnam caused considerable slippage in Military Construction Programs (MCPs), Emergency Military Construction Programs (EMCPs), and equipment acquisition. Power generation and supply remained a problem throughout the U.S. involvement in Vietnam.

The final daily problems to be discussed concerned potable water supply and sanitation in Vietnam. There were ample supplies of water in SEA but most of the water was contaminated and had to be treated to make it potable. Treating, storing, and supplying sufficient quantities of potable water was an ever present problem (244:3). Erdlators were used extensively to treat water but they were slow and required considerable backwashing to keep the filters from clogging and also needed extensive maintenance to keep them operational (20:atch#5). BCE personnel could not travel miles from their installations to obtain water because these sources could become insecure and place U.S. personnel in possibly hostile situations (149:6). In addition, these distant sources could be contaminated by the

enemy (149:6). As a result, wells had to be located on base and base wells were used at most USAF installations in Vietnam (152:10). In 1968, there were approximately 300 U.S. wells in Vietnam costing an average of $15,000 per well (152:10).

There were few sewage treatment plants in SEA. Treatment usually consisted of quick retention in septic tanks, to start digestion, with effluent discharged into the nearest ditch (208). Subsequent runoff contaminated much of the surface waters near U.S. installations compounding the water treatment problems facing BCEs. Waste water treatment remained haphazard at best as leech fields and septic tanks predominated throughout SEA (101:14; 152:10). It was fortunate there were no epidemics in SEA (101:14).

<u>Summary</u>. There were other problems which BCEs in Vietnam had to deal with. The problems with manning and personnel, supply, materials, power supply and distribution, water supply, and sanitation, which have been addressed here, were the most significant as indicated by the various end-of-tour reports and during interviews with AFCE contingency experts. These problems recurred throughout U.S. involvement in SEA but some relief was provided for the manning shortage through the Prime BEEF program, which is covered in the next section.

Vietnam and Prime BEEF

U.S. involvement in SEA began at the same time the Cuban missile crisis occurred. AFCE was no more prepared to respond to the Cuban crisis than it was to SEA requirements. In fact, civil engineering personnel were gathered to support the Cuban crisis by sending aircraft from base to base to pick up personnel. This support action did not follow any specific plan, and appeared to be accomplished on a random basis. According to Nethercot, in 1973, "the personnel required to support such a crisis, their skills, supervision, and general capabilities were unknown (167:11)."

Following the Cuban crisis, Major General R. H. Curtin, Director of Air Force Civil Engineering, initiated the development of a worldwide AFCE capability based on a United States Air Forces in Europe (USAFE) mobile team concept (56:1). USAFE had developed a mobile concept in order to support the Lebanon crisis of 1958, and the concept further proved itself during the Berlin incident of 1961 (167:10). Prime BEEF evolved out of the recommendation of a Joint Civil Engineering, Manpower and Organization Study Group, which had been formed in December 1963 to consider all the problems which prevented AFCE from fully supporting the Air Force mission. In an interview, General Curtin (now retired) stated that the actual driving force for the development of Prime BEEF was a need to formally justify the

wartime roles of military AFCE personnel to prevent a large cut in manning (58). Regardless of the reason for its development, the Prime BEEF program gave AFCE a long awaited means to respond to contingencies and this program would prove invaluable during the build-up in SEA (161:2; 58).

In October 1964, the Prime BEEF program was approved by the Air Force, the Civil Service Commission, and Congress (161:2). General Curtin implemented the program with the following summation of its implementation goals:

> The main objective of Prime BEEF is to create a civil engineering ability, within AFCE, to respond to emergencies. Therefore, no part of the Prime BEEF force will be in addition to the normal day-to-day validated work requirements. Individuals on the daily force will be designated to perform on teams in time of emergency. When mobile teams are deployed the home base must adjust to the situation until the team returns [56].

Originally, Prime BEEF was organized under a four team concept. BEEF-R (Recovery) teams were the largest teams and consisted of those personnel that were minimally essential to maintain base operations before, during, and immediately following an attack, or in the event of a major fire, flood, storm, strike, or similar emergency (161:2). BEEF-C (Contingency) teams were designed to deploy and augment BEEF-R teams. BEEF-F (Flyaway) teams were designed to deploy anywhere they were needed. BEEF-C and BEEF-F teams were 60 man teams, carried their own tools, and were manned to perform light construction, maintenance, and repair. BEEF-M (Missile) teams consisted of those personnel required to keep U.S. missile sites operational (161:2-5). Another

mobile team was later added (BEEF-LS) to satisfy the unique requirements of the Air Force Logistics Command (27:8-9). The force structure and skills necessary to meet the new Prime BEEF requirements were provided by realigning skills and by revising the AFCE military career field structure (161:3).

Table VI shows the assigning of personnel to teams, or posturing, during the early stages, with BEEF-C and BEEF-F teams only being established at a few designated CONUS locations (167:33):

TABLE VI

Prime BEEF Posturing

Team	Number of Teams	Average Team Size	Total Personnel
BEEF-R			
Postured	117	161	18,868
Sites,Stn			5,784
BEEF-C	46	60	2,760
BEEF-F	22	60	1,320
BEEF-M	10	97	974
BEEF-LS	1	77	77
TOTAL			29,783

Unfortunately, the initial development of the Prime BEEF program occurred when maximum team deployments would be required to support SEA operations. This caused a negative impression to be placed on the entire program, by both the general public and AFCE personnel, as merely a means of getting extra deployed personnel, on a TDY basis, into SEA

to bolster construction (167:9). For this reason, most personnel were initially placed on the non-deployable recovery teams to ease the transition and reduce the negative impressions associated with the program.

The first Prime BEEF team to be deployed was not sent to SEA, but to San Isidro Air Base in the Dominican Republic (172:16). Its mission was to support U.S. operations using a "Gray Eagle" mobility kit. "Gray Eagle kit" was the name given to a rapid deployment kit (developed by Tactical Air Command (TAC)) which encompasses all of the necessary support items for 1100 men. The kit included tents, mess equipment, housekeeping supplies, vehicles, lighting kits, and runway arresting barriers. The purpose of the kit was to allow rapid deployment to an expeditionary airfield, remain operational for a limited period of time, and then withdraw taking whatever could be salvaged for reuse (211:66).

This initial deployment was fraught with the same type of problems that would recur during subsequent deployments to SEA. The rapid employment of forces precluded any careful camp layout, causing tents and other structures to have to be relocated several times. There was a language barrier which made it difficult to obtain cooperation or support from local nationals. Although Gray Eagle Kits were established based on obtaining consumable supplies and materials locally, there were no such supplies available in

the Dominican Republic. Finally, there were no spare parts included in the Gray Eagle Kits for equipment or vehicle repair (172).

As the SEA build-up began, the already undermanned BCE forces were soon inundated with additional manpower requirements. BCEs welcomed the Prime BEEF teams and gave first priority to assisting them (78:7). The first Prime BEEF team in SEA was a small advance party which arrived at Tan Son Nhut Air Base in early August 1965 while the implementation program was still underway (211:83). This first team was an advance party for three larger teams which would arrive one week later. The primary purpose of these first few teams was the construction of protective structures for USAF aircraft.

Large numbers of USAF strike aircraft were deployed to SEA where pavement for aircraft parking was at a premium. Operational requirements made deployments necessary before adequate paving could be provided. This was an area of great concern as it compromised aircraft safety and increased their vulnerability to enemy attack. To reduce this risk, an urgent program for erection of aircraft revetments was started (211:40-41; 232:3).ARMCO steel bin revetments were developed and placed in expedited production (212:5). These revetments consisted of heavy corrugated steel walls set five and a half feet apart and twelve feet tall. Compacted earth was placed between the walls and

during tests at Eglin AFB these revetments successfully withstood the force of a 750 pound bomb and a 20 millimeter cannon shell (232).

On 15 May, 1965, USAF fears were realized when a tragic accident occurred at Bien Hoa AB. The explosion of a bomb on the wing of a loaded B-57 set off a chain reaction. Forty aircraft were destroyed, 26 Americans were killed, and over sixty were wounded. Just a few months later on August 24, 1965, forty five aircraft were damaged by a mortar attack on Bien Hoa AB (232; 190).

The urgency of the need for protective aircraft revetments was unquestionable. However, contractor and USA troop construction forces in Vietnam were already taxed to the limit. The USA was slow to respond to Air Force requirements because most of Army construction forces designated for Air Force support were in the Reserves. The bill which President Johnson had signed in 1965 did not allow for the mobilization of Reserve forces (211:41).

When PACAF requested Department of the Army support to construct aircraft revetments, the Army said its troop construction units were already dedicated to equally important Army projects and could not provide the support. HQ PACAF then requested, in July 1965, use of Prime BEEF units to construct the badly needed revetments. Hq USAF immediately requested the Major Air Commands to provide these teams for SEA deployment (211).

The initial teams consisted of three tailored, twenty-five man teams from the Air Defense Command (ADC), the Air Training Command (ATC), and the Strategic Air Command (SAC). The ADC team was hand picked from outstanding individuals throughout the command. It was led by Lt Col Francis E. Torr and team NCOIC MSgt Glenn H. Cooper, and was deployed to Tan Son Nhut AB (212:84). The ATC team was also hand picked from the entire command. It was led by Maj Forrest M. Mins, Jr. and team NCOIC CMSgt Clayton A. Wulff, and was deployed to Bien Hoa AB (212:85). The SAC team was from Biggs AFB, Texas. It was led by Captain Charles H. Martin and team NCOIC TSgt Nilas O. Manley, and was deployed to Da Nang AB (212:85). All three teams arrived at Tan Son Nhut AB in early August 1965 (212:86).

TABLE VII

Revetment Kit Arrivals

Date Docked	Kits
3 August 1965	1-for Tan Son Nhut
26 August 1965	9-(4)Tan Son Nhut (5)Bien Hoa
2 September 1965	17-Tan Son Nhut
9 September 1965	22-(17)Bien Hoa (5)Tan Son Nhut
10 September 1965	17-Da Nang

As the teams went to their respective bases, the previously mentioned supply problems surfaced again and hindered performance. In spite of the advance requisitioning of supplies, when the teams arrived on 8 August only one revetment kit had arrived for Tan Son Nhut. The next shipment did not arrive until 26 August and the Da Nang

team did not receive any kits until 10 September. Table VII summarizes the revetment kit arrivals for these initial teams (211).

All three teams, finding no kits to erect, directed maximum effort toward stockpiling fill. Each kit required 590 cubic yards (CY) of fill. The ADC team hauled and stockpiled over 15,000 CY. The ATC team constructed a 1.2 mile haul road and stockpiled over 8,800 CY. The SAC team stockpiled 10,000 CY obtained from hostile territory over 8 miles from the base. (212:88)

Each of the teams was augmented with 20 to 30 local nationals and during their 120 day deployment fully demonstrated the value of the Prime BEEF program. In addition to over 12,000 linear feet (LF) of the ARMCO revetments, PSP parking aprons and several miles of haul roads were constructed, concrete apron shoulders and revetment footings were placed, and several urgent facility projects were accomplished (212:5). The revetments recovered over half of the total cost of the revetment program in aircraft saves in just the first six months (190:63).

In 1968, the USS Pueblo was siezed and this action prompted a need for U.S. support in Korea. To demonstrate U.S. resolve to maintain its support and the sovereignty of South Korea, several fighter squadrons were deployed to Korea. This operation was called Combat Fox. Prime BEEF was used again and proved, as it had in SEA, to be essential to the rapid deployment and beddown of forces (179:2).

Dozens of Prime BEEF teams proved again and again the value of the concept during subsequent deployments to SEA. Table VIII summarizes some of the accomplishments of SEA Prime BEEF teams (38:5).

TABLE VIII

Prime BEEF Accomplishments 1965-1967

Revetments-27,000LF (5 miles)
Fill-in Revetments-over 53,000 CY
Blast Deflectors-9,300 SY
190 wood/metal, 1 story buildings-over 290,000 SF
50 wood buildings, 2 story-over 220,000 SF
Concrete ramps-3,700 SY
Concrete shoulders-2,700 SY
PSP removal-14,500 SY
Matting placed-55,600 SY
Grubbing and grading-8.5 acres
Drainage ditches-1,400 LF
Sanitary Sewers-1,800 LF
Water mains-19,100 LF
Tent frames-44,000 SF
High Intensity Lighting system
Runway Lighting cables-1,200 LF
Electric Service Drops-45 Buildings
Electric distribution system-16,000 SF
Modular Hospital (100-bed)-16,000 SF
Water wells, Field latrines, septic tanks etc.

Although Prime BEEF was very successful, there were still some inherent problems in the concept which prevented the development of its full capability. SEA-deployed teams were dependent on local BCEs. Since equipment and supplies had to be furnished by the BCEs, the problems which plagued the BCEs also affected the Prime BEEF teams (224:5). In spite of the fact that requisitioning had been done well in advance, through both USAF and local procurement channels, there were times when essential supplies, equipment, and materials simply could not be obtained (78:7). Again the

USAF supply system proved itself too slow in SEA and most needed items were not available locally (78:7). If BCEs were unable to obtain supplies or equipment, Prime BEEF work was stopped. If materials were on hand but amounts were critically low, Prime BEEF was given first priority and BCE construction programs were delayed (78:7).

One side point, seldom mentioned, concerns the home stations of the deployed teams. BCEs at home stations were the manning resource pool for the SEA deployments. It is a credit to these organizations that they could still maintain base operations even with their decreased manning (224:7).

The Prime BEEF concept was proven in SEA. Team members typically exhibited very high espirit de corps. They unhesitatingly worked where they were needed, even if that meant working outside their Air Force specialty (234:23). Prime BEEF teams were respected throughout the Air Force yet there were many things Prime BEEF could not accomplish due in part to their relatively small size and their dependence on SEA BCEs. Additional Air Force troop construction forces were still required. The next topical area to be covered concerns Air Base construction in Vietnam and includes a section on the development of the Air Force's heavy repair squadrons (RED HORSE).

<u>Air Base Construction in Vietnam</u>

<u>Introduction</u>. As mentioned earlier, there were many problems associated with air base construction in Vietnam. There were numerous old French and Japanese airfields in

Vietnam but these were primarily short dirt runways with few supporting facilities (185:39). They were adequate for the aircraft and operations that were used in World War I and World War II but they were grossly inadequate for modern jet aircraft operations (226:4). Existing airfields required extensive construction to make them capable of supporting modern aircraft. In addition, operational criteria made it necessary to locate other bases on essentially virgin, unimproved land.

The U.S. Navy had an established construction agency in the SEA region. In 1958, the Secretary of Defense directed that all military construction in SEA, regardless of service, be accomplished with the U.S. Navy as the construction agent (211:8). The Navy Officer in Charge of Construction (OICC) had overall responsibility for SEA and the Deputy Officer in Charge of Construction (DOICC) had responsibility for Vietnam (211:9). CINCPAC delegated to MACV the responsibility for coordinating all real estate actions among the services in Vietnam, for handling all related negotiations with the South Vietnamese government, and for developing construction standards for all the services (211:10). MACV delegated some of this responsibility to each service branch in the region. The PACAF Deputy Chief of Staff for Civil Engineering was to provide planning, programming, design guidance, construction, and O&M for the USAF throughout SEA.

Because of the decision not to mobilize Reserves for Vietnam, it was decided to use a single large, contractor combine for Vietnam. In 1962, U.S. government construction in Vietnam became the responsibility of a joint venture known as RMK-BRJ. This contractor combine was made up of Raymond International, Inc., of New York City; Morrison-Knudsen Co., Inc., of Boise; Brown & Root, Inc., of Houston; and J. A. Jones of Charlotte, North Carolina (143:24). In reality, the Navy's cost-plus-fixed-fee (CPFF) contract with RMK-BRJ was basically a management contract since the contract involved primarily management and supervisory personnel from each of the respective companies (78:5). This arrangement was sufficient in getting long range MCP accomplished, provided high quality designs, and the CPFF incentives kept time slippage to a minimum. However, Navy OICC capability was not capable of handling the urgent or unforeseen requirements generated by the rapid build-up of U.S. forces in SEA (78:8). The massive mobilization of this single contractor combine for the billion dollar construction program in Vietnam, under wartime conditions, significantly complicated the management and control task (212:22; 158). This brief introduction on the responsible construction agencies and contractors sets the stage for further discussion.

The next several sections present a more detailed discussion of problem areas concerning air base construction

in Vietnam. The first section explains the programming, funding, contracting requirements, design, and construction materials used in Vietnam; the second section discusses the development of the Air Force's troop construction capability (RED HORSE); and the final air base construction section discusses the unorthodox, at the time, yet extremely successful turnkey construction of the base at Tuy Hoa.

Construction. In 1961, the first MCP projects were programmed for Vietnam, and the "Charging Hawk" project was initiated to find suitable terrain for the erection of bases with the least possible delay (226:4). At the time Cam Rahn Bay and Phan Rang were bare lands along the sea coast, and the Tuy Hoa and Phu Cat sites were not identified for possible construction (226:4). As mentioned earlier, only limited construction went on up to 1964.

Prior to 1964, U.S. military participation in Vietnam was primarily through the Military Assistance Program (MAP) and Aid In Kind (AIK). The intention of MAP in Vietnam was to provide needed construction for items peculiar to the needs of the host country. Many of the line items of SEA MAP sub-missions were of a joint use type and MAP and MCP paralleled each other in their programming requirements and objectives (211:8). The AIK funds were used to bolster the South Vietnamese economic structure and limit the gold flow out of the US. These funds, which were spent in Vietnamese currency, were used to buy in country items for construction, maintenance, and repair; for payment of local national

salaries; and for leases (211:20). As the build-up accelerated, MCP, MAP, and AIK procedures proved unresponsive to satisfying the requirements associated with the rapid build-up (211:8). As a result an extensive amount of accelerated MCP had to be accomplished and an Emergency MCP had to be initiated.

Normal DOD procedures for authorization and funding of facilities were not responsive to the remote, fast moving force deployment associated with the build-up in Vietnam (34). The in-country major construction program was MAP funded and was programmed and monitored by (MAAG) Air Force (244:2). There were many conflicts with MAAG Air Force, 2nd Air Division, and the South Vietnamese Air Force each running construction programs separately (244:2).

In order to try keep pace with the build-up an extensive amount accelerated MCP (P-341), construction was programmed. In fact, most of 2AD's construction was P-341 funded with the largest line item being under $200,000 (Woodworth:2). Even with the decreased lead time associated with P-341, procedures were still too slow. As a result, expedited P-341 authority was granted by the Secretary of Defense in October 1964 which provided a means to rapidly approve and initiate emergency construction. These expedited procedures allowed submission of projects by message with approval by return message (212). However, these procedures provided only short term relief until new funding procedures could be established (211).

There was much concern over construction program funding. Congress felt that the piecemeal submission through P-341 channels was inefficient and wanted to see an overall program package. Air Force concerns over project funding are best expressed in the following quotes by General Hunter Harris (CINCPACAF) and Colonel Henry J. (Fritz) Stehling (PACAF Deputy Chief of Staff for Engineering):

> The Pacific Air Forces ability to provide timely, adequate facility support of current and planned contingency operations in South East Asia is of great concern. Construction support is limited primarily because of the inability of command resources to respond in a timely manner. Aircraft, weapons, equipment, and personnel requirements are prepositioned or programmed on mission needs. However, the lead time required to obtain facilities is too long due primarily to complex procedures and criteria.
>
> There is neither adequate authorization nor funds available for rapid response to construction requirements. Also, there is a requirement to provide, distinct from existing peacetime measures, construction authorization and funds to support contingency operations. A memorandum JCSM 987-64, 25 Nov 64 forwards this conclusion to the Secretary of Defense and recommends that authority and funds in the amount of $150 million be obtained, without the stringent project limitations now incorporated in various laws [211:23].

The groundwork was laid for PACAF to establish a packaged program for Vietnam. This 1965 Emergency MCP (EMCP) initially called for $14.8 million, with an additional $41.2 million being provided through the Supplemental MCP (SMCP) in 1965. In addition, ammunition storage programs were initiated which provided another $2.6 million (211:25). However, continuous analysis by command evaluation and review panels, keenly aware of the escalation of the war

effort, identified requirements over and above all previous estimates. On 7 December 1965, the Secretary of Defense approved a package of $337.5 million (211:26). Even with these large appropriations, bases still had to be planned, sited and designed. These concerns presented additional challenges for AFCE.

The primary site selection requirements dealt with operational considerations. The overriding requirement was obviously tactics and strategy which included the types of aircraft, their range, load carrying capacity, and the location of the enemy. Once the proposed site was identified, the Vietcong had to be cleared and security had to be sustainable with minimum ground troops. Most bases had to be located near deep water ports so that logistics support could be maintained. Flight hazards such as intersecting traffic patterns and topography had to be considered. When these requirements were met, the U.S. had to acquire the necessary real estate. Even though airfields were constructed in countries at war, the U.S. still had to abide by the laws of the land. Vietnamese laws did not differ greatly from U.S. laws but they were restrictive and considerable time was needed to acquire land.

Much of the terrain in SEA was unsuitable for air bases because of mountainous conditions and delta regions (226:4). Civil engineers had to evaluate grading and drainage requirements, soil conditions, the availability of construction materials, water for both domestic and industrial

purposes, and local labor sources. However, civil engineering considerations often took a back seat to the primary considerations and which drove construction cost ever higher: more than doubling the costs when compared to similar construction in the CONUS (78:9). The tempo and complexity of the build-up made reasonable programming difficult. The arrival of additional civil engineering personnel also lagged the build-up keeping USAF engineering capability at a low level (211:10).

Operational considerations made it necessary to locate many new bases as quickly as possible. As the first contracts were awarded requirements mushroomed making all pre-planning invalid. For weeks, it was nearly impossible to determine the number of personnel who would be at any location. The hastily located airfields were placed in delta regions with sandy or silty soils which created problems with soil erosion and runway maintenance (101:14).

After the sites were selected , designs had to be accomplished and construction contractors and materials had to be marshalled. The basic tactical support expeditionary airfield consisted of a 3500 by 60 foot runway plus parking for three C-130 aircraft. USAF had the responsibility for certifying airfields before allowing aircraft to use them (185:113). More permanent airfields required 4500 to 7000 acres (190:61). The next few paragraphs address: 1) project approval and designs ;2)the airfield materials used and ;3) the techniques and materials used for supporting facilities.

The 2AD, staffed with one engineering officer and one civilian in 1965, had responsibility for managing the entire Vietnam construction program (78:9). Projects had to be submitted through the 2AD and then followed one of two paths. If the estimated project cost was under $25,000, the project was approved and sent to the Navy OICC. If the estimated project cost was over $25,000, it had to be submitted to HQ USAF for inclusion in P-341 or the MCP. Although the expedited procedures for P-341 provided approval of some projects in as little as two weeks, this was the exception rather than the rule and projects were delayed, sometimes for months, before being approved (78:9).

Another problem, which limited the development of the Navy OICC's full capability, was the policy requiring a complete and detailed design before negotiating the CPFF contract with RMK-BRJ. A detailed design is essential during peacetime when competitive firm fixed price bids are received on nearly every project and precise definition is required to minimize contractual difficulties. The urgency of the need to provide facilities in the shortest amount of time far outweighed what few advantages there may have been in requiring finished designs (78:9). An example where finished designs are not necessary is in the construction of a diesel-electric power plant. A detailed power plant design was extremely time consuming. This time could have been better utilized by turning the manufacturer's brochures

over to the CPFF contractor, along with recommended foundation dimensions, and allowing the contractor to build the power plant from the manufacturer's drawings and details (78:9).

Airfields were considered of vital importance. General Westmoreland realized that aviation would play a key role in jungle warfare and the mobility of troops and supplies depended on the availability of airfields at strategic points throughout the country (185:25). Concrete runways were best suited for sustained jet aircraft operations and several of these had been prepared in Thailand (190:112). However, these runways had been underdesigned and quickly failed when subjected to heavy use by modern jet aircraft (149:7).

Because of the relative ease of construction, asphalt was used for most airfield construction in Vietnam (190:112). However, the asphalt surfaces were subject to excessive wear and constantly required patching. As a result, several expedient airfield surfaces were tried in Vietnam. These included perforated steel plank (PSP), M8-A1 solid steel plank (SSP), MX-19 square aluminum matting, AM-2 aluminum matting, and the T-17 membrane.

PSP had been used extensively in WW II and Korea, and was readily available for expedient airfields in Vietnam. Many of the problems experienced with PSP in previous contingencies were again present. These included the washing out of subbases due to the torrential rainfalls in Vietnam,

and the resulting maintenance problems of having to torch cut, replace, and weld failed sections (227:4). The Army's construction battalions did not like using PSP for these reasons (185:113; 212:10).

The M8-A1 solid steel plank and MX-19 square aluminum mat were only slight improvements over PSP. The soil stabilization problems were less severe with these surfaces, but plank and mat joints could not be sealed completely against the heavy rains. This again resulted in the washout of bases and the failure of these surfaces. Late in the conflict, rubber inserts were developed which helped to resolve this problem; but, they were provided too late to make a significant impact (185:113).

Aluminum, AM-2, matting was considered the best expedient surface for jet aircraft operations (159). This matting worked very well during its design life, but often AM-2 surfaces were used far beyond that point (34). The abrasive surface of the AM-2 would quickly wear away making it difficult for aircraft to brake and turn. This problem was magnified on water slick aluminum matting (101:14). When sections did fail they also had to be replaced by cutting and welding.

One surface which was used for relatively short term operations was the T-17 membrane. This surface consisted of a tough rubberized fabric which could be placed at the rate of 200 LF per hour with a work force of 100 men. The T-17 membrane proved highly successful as an expedient airfield

surfacing material. It was quickly installed and provided a durable, waterproof, dustproof surface (185:113).

Once the airfields were constructed, supporting facilities had to be built. These included POL systems, operational facilities, messing facilities, billeting, etc. The next several paragraphs describe the construction materials and techniques that were used and should have been used in Vietnam.

There were many different types of structures used in SEA. These included tents, trailers, wood frame and inflatable shelters, and masonry structures. The prefabricated trailers were well received, easily setup, and had low maintenance requirements. However, getting these trailers into Vietnam and to then transported to the bases was difficult; consequently, they were used only sparingly (190:112). Masonry structures were the most durable, but only well established air bases SEA received these structures (190:112). Modular facilities were also fairly successful, but they were not available until late in the build-up (190:63). Each type of structure used had its own set of problems adding to the woes of the BCE in Vietnam.

U.S. war making hardware used in Vietnam was exceptionally advanced and paralleled state of the art technology. However, U.S. construction hardware and technology, applicable to support warfare operations, was often outdated. There were no prefabricated packages that could be loaded on aircraft, and with minimum site development, be

assembled and used for any extended period for sheltering troops, or for administrative facilities, command posts, or other operational facilities, let alone for power generating plants which were capable of expanding as power demands increased (208:2).

The tents used in Vietnam were essentially the same type Hannibal had used in crossing the Alps (149:3). To prolong the lives of the tents they were placed over wood frame structures with wood floors. One variation consisted of placing a corrugated steel roof on the tents which significantly prolonged their lives. Invariably tents proved to be an expensive alternative because they needed frequent replacement and required extensive maintenance (190:112).

Buildings were usually adaptations of local type construction. "Hootches", which described a one or two story, wood frame building, constructed to local standards, became a common word in the U.S. military vocabulary (149:4). Civil Engineers at Tan Son Nhut developed a successful variation on the wood frame buildings (78:4).

They developed a simple, versatile, wood frame design which consisted of modular sections fabricated in BCE construction yards. These sections were twenty feet wide and were placed in twenty foot sections. The walls were placed on four inch concrete slabs. Prefabricated trusses were then put on the walls and the structures were roofed with asbestos cement. To allow ventilation, the tops and bottoms of walls were left open and insect screens were

placed along the entire wall. These structures proved useful for troop housing, warehouses, medical dispensaries, and operational buildings. In one year, over 200,000 square feet of the wood frame structures were constructed by the construction division at Tan Son Nhut (78:4).

Wood structures were the most used in Vietnam (Corona:4). They generally provided a rapid means of supporting operational and base facilities. However, climatic conditions and the devastating attacks by termites caused a high replacement, maintenance, and repair effort to keep facilities in usable state (20:7).

One new development used in Vietnam was the inflatable structure (149). There were basically two types of these shelters: 1) a single wall, balloon like structure, supported by internal air pressure; and 2) a double wall, cellular type where only the wall sections were pressurized (211:39). Both types maintained air pressure with electrically driven pnuematic pumps (149:2). In 1965, there were 99 single wall types and 384 double wall types covering over six acres in Vietnam (211:40). The biggest problem with the inflatable structures was insuring that a reliable power source was available to keep the electric pumps running (149:2).

Many of the problems associated with programming, funding, contracting requirements, design, siting, and construction materials used in Vietnam have now been

addressed. The next two sections present a discussion on some solutions to some of these problems that the USAF experienced in Vietnam.

AF Heavy Repair Squadrons (RED HORSE). It became evident that the small Prime BEEF teams, used on a TDY basis, relying on their own tool kits and heavily dependent on local BCEs for equipment and materials, could not fully cope with the rapidly expanding requirements associated with the build-up of U.S. forces in Vietnam (212:6). Contractual efforts were logically concentrated on large scope, high cost, heavy construction requirements of new airfields, runway extensions, parking apron expansions, and sophisticated technical facilities (212:7). Troop construction support was sorely needed for critical facilities.

The advantages of troop construction versus contract construction in a wartime situation include (212:15-16):

a. Costly contract negotiations, administration, and accounting procedures are minimized.

b. Troops are more adept at living under austere field conditions.

c. Troop construction units can provide their own security, which must be provided for contractors by other military units.

d. Troop units can rely on established military logistics systems.

e. Troop construction units are more familiar with unique military requirements.

f. Troop construction units are not affected by strikes or other labor disputes.

The United States Army (USA) and United States Navy (USN) had well-established troop construction forces and were typically responsible for providing all troop construction support for the USAF. The existing agreements to provide this support were based on Joint Operation Plans involving major wartime situations and did not apply to the limited war in Vietnam. There was an unacceptable lead time for AF component commanders to obtain support from unified commanders because of the tremendous requirements placed on all troop construction forces in Vietnam (188:1). USAF requirements typically took a back seat to the requirements of the other services as expressed in the events concerning the aircraft revetments which led to the use of Prime BEEF in Vietnam (see Prime BEEF section).

In May of 1965, a group of U.S. Marines and Seabees landed during an amphibious assault at Chu Lai, 50 miles south of Da Nang, and once secure, initiated construction of an expeditionary airfield. In just twenty-three days, they constructed a 3500 foot runway with AM-2 matting from which Marine tactical air support operations were conducted (190:6-126). This prompted the Secretary of Defense to write a memo to ask if the Air Force had a heavy operation and repair troop construction capability.

The study resulting from this memo concluded the Air Force did not have such a capability (211:91). In fact, AFCE did not have any of the following capabilities (188:1):

a. To perform bomb damage or disaster recovery when such repair was beyond base capability.

b. To support tactical force deployments when national interests are involved, particularly when such support may be required without declaration of war.

c. To provide expeditionary airfields and austere support facilities in combat areas for tactical AF units, pending assignment of construction troop support by either the USA or USN.

Just four months after the incident at Chu Lai, PACAF sent a proposal to HQ USAF which outlined the requirements for a more stable and capable heavy repair and emergency construction capability (190). The initial concept was to provide mobile troop construction capability, organic to the Air Force, which could perform heavy repair, emergency minor construction, and upgrading of airfields and facilities (190:127). The AF units would not have the capability to: 1) perform heavy construction of semi-permanent or permanent airfields; 2) establish local security; or 3) conduct a sustained deployment to a "no base" site (188:2).

HQ USAF quickly adopted this idea and swiftly obtained the Joint Chiefs of Staff and Secretary of Defense approval (190:127). In October of 1965, HQ USAF ordered the 554th and the 555th RED HORSE squadrons assigned to PACAF (190). These squadrons each consisted of 388 enlisted men and 12 officers, and accomplished their training at Canon AFB, New Mexico (190:127). These 400 man construction squadrons were considerably smaller than the USA construction brigades and the USN Seabee units. The following list includes the most significant RED HORSE capabilities (188:atch 1; 62):

a. Provide an engineering staff element to establish an installation recovery plan.
b. Provide an advance survey team.
c. Expedient bomb damage repair of airfields.
d. Soil and terrain analysis.
e. Construction of expedient airfields.
f. Construction of cantonment areas.
g. Provide airfield lighting.
h. Provide limited POL support, such as above ground fuel bladders
i. Perform field maintenance on construction equipment and vehicles; not overhauls.
j. Asphalt work as required.
k. Operate, maintain, and repair power generators.
l. Provide shallow wells, less than 250 feet deep.
m. Operate a field mess.
n. Operate a field medical dispensary.
o. The entire unit, including equipment, was air transportable.
p. All personnel were small arms proficient.
q. Operate for at least 90 days independent of support from any base.
r. Install aircraft arresting barriers.
s. Be organized to deploy in limited "blocks" of required skills as necessary.

In order to prevent any conflict between the services, and to insure that the Air Force did not compete for the traditional jobs of the USA and USN, the purpose and mission of RED HORSE was at first restricted. In addition, it was initially planned to disband the RED HORSE squadrons after U.S. involvement in Vietnam ended (58; 63). The position of the Air Force is explained in a November 29, 1965 letter from the Air Force Chief of Staff to the CINCPACAF:

> Our stated position is that we want to organize heavy repair squadrons to repair airfield damage caused by enemy action or natural disasters, and that the quadrons are not designed for but will have a collateral capability to build expeditionary or temporary airfields and do other construction work of an emergency nature ... in other words, our squadrons can work on airfields after they are built and the Engineers and Bu Docks people have left [57:128].

However, this restrictive use policy was quickly overcome by events, and at Phan Rang Air Base, the 554th CES worked side by side with Army Engineers in keeping expeditionary airfields open (189).

Eventually there were six RED HORSE squadrons in Southeast Asia: 1) the 554 CES, first at Phang Rang,then Cam Rahn Bay and Da Nang; 2) the 555 CES at Cam Ranh Bay; 3) the 556 CES at U-Tapao, Thailand; 4) the 819 CES first at Phu Cat then Tuy Hoa; 5) the 820 CES first at Tuy Hoa then Da Nang; and 6) the 823 CES at Bien Hoa (19:8; 165).

Still more manpower was needed and these squadrons had to be heavily augmented with local nationals. There were greater than 6000 local nationals working for these RED HORSE squadrons in September of 1967 (190:129) and RED HORSE personnel acted more as supervisors and less as workers. The RED HORSE squadrons were responsible for and participated in the construction of every type of facility in Vietnam. At Tuy Hoa, the 820th RED HORSE squadron was directly responsible for 50 percent of all the construction at that base. All over Vietnam, RED HORSE excavated more than 2 million cubic yards; put in many miles of roads; poured ten of thousands of cubic yards of concrete; constructed hundreds of thousands of square yards of expeditionary airfields, taxiways, and parking aprons, as well as millions of square feet of facilities; and accomplished extensive bomb damage repair (22). RED HORSE squadrons were

extremely successful in Vietnam and proved the Air Force could organize, maintain, and sustain their own troop construction capability.

Retired Brigadier General Archie Mayes argues that RED HORSE units were more capable and better equipped than their U.S. Army and U.S. Navy counterparts. Because RED HORSE was a new development, they were not tied to an outdated table of allowances for their equipment needs. The Air Force was free to buy whatever new equipment the units might need. Because RED HORSE units were manned from existing AFCE specialists, only minimum training was required to achieve full capability (161; 212). The airmen and officers were superbly qualified.

Prime BEEF and RED HORSE were separate and apart from each other but they supplemented and complemented one another. The Prime BEEF teams and RED HORSE squadrons in SEA created a new image for AFCE. Their skills and authorization to complete MCP, P-341, and O&M projects rapidly gave USAF commanders in Vietnam vital facilities on a timely basis and proved AFCE "can do-will do" (19:8; 159).

Turnkey Construction at Tuy Hoa. As mentioned earlier, all military construction in Vietnam had been entirely in the hands of RMK-BRJ starting in 1962. It was normal procedure for the OICC's CPFF contractor to handle all construction. However, if a critical priority existed and contractor capabilities were committed to even higher priorities, MACV Director of Construction could allow the

Air Force to find its own contractor (38:3). The Air Force needed another base for tactical fighters before the end of 1966; but, the Navy OICC said that the soonest he could provide the base, using RMK-BRJ, was June 1967 (143:26). This was unacceptable.

It was jokingly proposed by Navy OICC personnel that the Air Force obtain their own contractor for Tuy Hoa (159; 6). However, the USAF took the proposal seriously and the concept to use a CPFF, design-construct, contract monitored by a decentralized construction agency, apart from RMK-BRJ, which was known as Project Turnkey (190:169). There was considerable skepticism from the MACV Director of Construction, the Army Corp of Engineers, and the OICC (226:4; 149:26; 38; 159) about the Air Force's ability to accomplish Project Turnkey. However, General Westmoreland (MACV Commander) stated we needed a base and pushed to allow the Air Force to try it (143:26).

The JCS approved Project Turnkey and it was spearheaded by the Directorate of Civil Engineering, HQ USAF, by Brigadier General Guy H. Goddard, Deputy for Construction. The organizational plan was a joint effort of the Deputy Chief of Staff for Civil Engineering, HQ PACAF (Colonel Henry "Fritz" Stehling), the 7AF Civil Engineer (Colonel Archie Mayes), and the Directorate of Civil Engineering, HQ USAF (38:2). On May 31, 1966, a contract was signed with Walter Kidde Constructors, Inc., of New York (38:3; 143:24).

RMK-BRJ argued that their construction program, then worth $500 million, was already straining the market for construction materials and equipment, the capacity of Vietnam's ports, the ability of Pacific shipping, the Vietnamese labor market, and the Vietnam economy (143:24). AFCE set up certain ground rules to isolate Project Turnkey from RMK-BRJ construction (143:25). These ground rules were:

1) All men, equipment, and materials had to come in over the beach at Tuy Hoa.

2) Multi-skilled U.S. labor would build the base with local labor coming only from the Tuy Hoa area.

3) Workers were paid only five percent of their wages in Vietnam with the remaining ninety five percent being deposited in accounts in the US.

4) Project Turnkey equipment and materials had to be shipped from East Coast and Gulf ports.

5) U.S. employees had to stay out of local politics and their conduct and impact on the local nationals and the economy had to minimized.

Project Turnkey was the first design-construct contract the government had awarded since WW II and was the first time during the Vietnam conflict that anyone but the Navy's OICC had handed out a construction contract in SEA (143:24). The project was to include two runways for jet operations, a four thousand man cantonment area, operational failities, POL, and the necessary supporting industrial plant (190:141). In addition, certain incentives for Kidde were written into the contract for early completion (143:24).

The first runway was completed six weeks ahead of schedule (143:26). It was a 9000 by 150 foot AM-2, runway. Kidde's subcontractor for horizontal construction (B.B. McCormick & Sons, Inc. of Jacksonville, Florida) built this runway under time and under cost in spite of the extremely heavy and early monsoon rains (143:26). The second runway was a parallel, 9500 foot, concrete runway (143:26). Vertical construction work at Tuy Hoa was simply designed and construction consisted primarily of the erection of prefabricated, modular facilities (143:26).

Project Turnkey was completed in just 210 days. It allowed four F-100 squadrons to be bedded down in December of 1966 and the entire project was completed under time and under cost (190:141). Project Turnkey also demonstrated the value of using off-the-shelf materials and equipment (191). Since AFCE was its own procurement authority for this project, they were able to purchase readily available commercial products foruse at Tuy Hoa. Kidde was able to use familar, proven, materials and equipment, with minimum procurement leadtime (159). Tuy Hoa's construction was the fastest, most economical, and the best controlled construction project in Vietnam (226:4; 159; 191).

Air Base Construction Summary. This final topical area on Vietnam has presented a discussion of Air Base construction. There were many problems concerning construction programming, funding, siting, design, and construction materials and methods used in Vietnam. However, there were

two significant success stories for AFCE in Vietnam: 1) the establishment of the USAF's own troop construction and heavy repair squadrons (RED HORSE); and 2) the design-construct, Project Turnkey, construction of Tuy Hoa Air Base which clearly demonstrated the USAF capability to act as its own construction agent.

This topical area is closed with the caution that AFCE should not get enamored with design and construction. AFCE is not staffed for nor is it given the necessary resources to act entirely as its own construction agent. As General Curtin pointed out to the delegates of a 1966 PACAF conference :

> The Air Force has typically been oriented toward Operation and Maintenance (O&M), accomplishing only enough construction to maintain a professional edge for day-to-day accomplishment... we are O&M! [233:25]

VII. Post Vietnam Era (1975-1985)

Introduction

AFCE made major strides toward improving its support of the Air Force mission during the Vietnam conflict. A long awaited means for AFCE to respond to contingencies was developed and implemented in the Prime BEEF program. However, there were inherent problems with the small, TDY, teams having to rely on BCEs for equipment and materials. These limitations led to the development of RED HORSE, which gave the USAF a troop construction capability, organic to the USAF, and which could operate independently of any base for limited periods of time. The unique, yet extremely successful, Project Turnkey, where the USAF acted as its own construction agent for a CPFF design-construct, contract to build Tuy Hoa AB, was another significant success story for AFCE.

As US involvement in Vietnam decreased the funding for military construction also decreased, as is the case in most post-war eras. PACAF had large military construction budgets during the Vietnam era; however, this money was used primarily in Vietnam and other PACAF bases suffered (91). In addition, the large Vietnam program drew down the military construction authorizations of other MAJCOMs. In the years following the Vietnam conflict, AFCE was faced with a

constant battle for not only new construction dollars but for O&M funding as well (163; 191; 91; 159). Facilities at bases throughout the USAF suffered.

Many of the gains made in troop construction and AFCE mobility were faced with possible extinction. The Prime BEEF and RED HORSE units in Vietnam had such an outstanding performance record, that initial agreements to disband the units were put aside. However, the US Army wanted to regain control over these construction units.(165; 183)

The US Army had always been responsible for USAF construction support during contingencies; however, their performance in providing this support has never been adequate to accomplish all USAF requirements. The US Army's treatment of USAF support requirements has been to assign units to accomplish the support on a national basis. Many of the units that were designated for USAF support were either grossly undermanned and equipped, or did not exist (154). This arrangement came under close scrutiny and as Maj Gen Gilbert has stated:

> No, I will not depend on, you (DOD) cannot afford, to put reliance on national forces for such an important leg of your fighting force as the Air Force, and the Army has never been able to support the Air Force [91].

In 1978, the issue was decided by the Joint Chiefs. The JCS directed a Joint Contingency Construction Requirements Study (JCCRS) which took two years to complete. The Air Force eventually won t e issue and retained control

of their troop construction units. The need for the existence of Prime BEEF and RED HORSE had been justified by the JCCRS and the JCCRS became the basis for future AFCE manning and tasking.

This turning point for AFCE did not occur until several years after the Vietnam conflict ended. The skills, espirit de corps, and accomplishments and RED HORSE and Prime BEEF in Vietnam spoke for themselves and helped to win the issue for the Air Force. However, the organization and posturing of these units was still an issue to be debated and there were many lessons learned in Vietnam.

Various end-of-tour reports provided a good account of the events, pertaining to AFCE, during the Vietnam conflict (see chapter VI on Vietnam). There were many lessons learned during the Vietnam conflict and Colonel Henry "Fritz" Stehling, HQ PACAF, Deputy Chief of Staff for Civil Engineering, for several years during the Vietnam conflict, summarizes some valuable lessons in a 1967 article (213):

a. AFCEs should expect the worst possible conditions and all contingency plans should be based on actual site surveys.

b. AFCEs should have an understanding of combat air operations.

c. AFCEs should become familiar with, and obtain a better understanding of, harbor engineering practices.

d. Company grade AFCE officers need to be familiar with heavy construction techniques and keep abreast of new technology.

e. AFCE should be able to adjust its management according to changing international, economic, and environmental conditions.

f. AFCE should computerize during peacetime and develop the system for wartime uses.

g. AFCEs should be familiar with military affairs and keep abreast of new developments.

Again, during his testimony before a congressional committee, Colonel Stehling provided the following additional recommendations for AFCEs in future contingencies (212:21-23):

a. AFCEs should be a participant in the development of contingency plans.

b. AFCE should be provided adequate manning.

c. In country logistics supply channels should be established as soon as possible.

d. Maximize the use of pre-engineered and prefabricated structures to cut construction leadtime.

e. The massive mobilization of a single contractor complicates the management and control task.

f. Flexible programming avenues should be available for contingency support.

g. Troop construction and turnkey combinations were the most effective method of providing contingency construction.

h. Construction agent responsibilities should be decentralized.

i. Civilian contractors could be relied on under hostile conditions.

These lessons and recommendations concurred with those contained in the various end-of-tour reports, Project Corona Harvest which was a extensive after action report of the

Vietnam Conflict, and the comments of various AFCE contingency experts (191; 159; 58; 163). Some of these lessons and recommendations have been adopted in the post Vietnam era; however, many have simply been ignored.

This chapter presents a discussion of the post Vietnam era and is divided into five sections: 1) Prime BEEF recovery operations and training; 2) Bare Basing and support kits; 3) AFCE research and development; 4) Rapid runway repair; and 5) AFCE contingency planning.

Prime BEEF Recovery Operations and Training

Recovery Operations. As Prime BEEF was still a new development in Vietnam the concept was also proving itself to be ideal for recovery operations. Prime BEEF teams have not only been used on Air Force installations but, in support of US Army posts and civilian communities to help in putting them back on their feet after natural disasters (21; 100; 204; 235; 247). The following paragraphs describe several instances where Prime BEEF's recovery mission has been exercised.

In September 1965, Hurricane Betsy hit Florida. The Hurricane battered Homestead AFB and the scope of the damage repair was beyond base capabilities. The weather cleared and within 36 hours a 91 man Prime BEEF team was on hand to aid in recovery operations. Although the Prime BEEF concept was still in its infancy the standards for skill levels,

number of technicians, equipment authorizations, and mobility proved highly satisfactory for recovery operations (2:18-19).

The Alaskan flood of August 1967 provided the first instance for Prime BEEF to be used in support of another military service. The flood caused over $177 million in damages to Fairbanks and Fort Wainwright. The Army's recovery units were dedicated to recovery operations in Fairbanks and they did not have sufficient mobile units to aid in post recovery. Prime BEEF support was eventually requested and when they arrived there had been no electricity, heat, water, or sewers in all of post housing for twelve days (219). Prime BEEF set right to work and their efforts did not go unnoticed as indicated from the following quote from a memo from General Harold K. Johnson, USA Chief of Staff, to the USAF Chief of Staff:

> Inundation of the entire post caused the utilidors to be completely flooded which, in turn, resulted in an almost total paralysis of the utility systems. With the assistance of your highly skilled technicians and craftsmen who were quickly dispatched to Fort Wainwright, excellent progress is being made in the restoration work, and many of the most essential services have now been resumed . . . I should appreciate your conveying to the officers and airmen concerned my sincere gratitude [219].

There were several opportunities for Prime BEEF to perform their recovery mission in the early 1970s. There was extensive damage to Rapid City, South Dakota due to severe flooding. There was only minimal damage to Ellsworth AFB so base engineers, accompanied by 1500 base personnel,

were quickly mobilized and led recovery efforts in the local community (235). Hurricane Agnes hit Wilkes-Barre, Pennsylvania and many civilian families were left homeless. Prime BEEF teams worked with the US Army Corp of Engineers in repairing and getting over 32130 trailers ready for the displaced families (204). When a large tornado devastated the town of Xenia, Ohio, Wright-Patterson AFB engineers and members of the 820th RED HORSE helped that community recover (247). When an earthquake devastated the Fruili region of northern Italy, engineers of the 3400th CES from Aviano AB aided in recovery efforts (100).

Training. The experiences and accomplishments of AFCE in Vietnam provided the Air Force with its most capable engineering force in its history. However, as time went on, AFCE was faced with losing its wartime edge. New Prime BEEF and RED HORSE members were inexperienced in contingency operations and the uses of RED HORSE in peacetime had to be established (154). As conditions in South West Asia became more turbulent and the US realized its dependency on the oil reserves of the region, it became apparent that a highly trained mobility force had to be maintained. However, it was not until the late 1970s that major exercises were held to attempt to familiarize personnel with contingency operations.

Exercises such as Jack Frost, Peace Pharoah, Proud Phantom, Salty Mace, Red Flag, and Bright Star now occur regularly. Many of the problems associated with logistics

and day-to-day operations which occurred in Vietnam, continued to be experienced (53; 205; 74; 203; 240); however, these problems are minimized as more personnel become trained. Unfortunately many of the details of these recent exercises are classified and cannot be made available to all of AFCE.

New problem areas, not experienced in Vietnam, are those associated with conducting full Wing operations in chemical warfare gear. Existing gear is cumbersome and restricts movement. Work shifts must be shortened because of the severe heat stress conditions while working in the gear. Although this is a major problem area an improved chemical suit is not technologically available nor economically feasible (203;42).

In addition to the major exercises, AFCE receives contingency training in other forms. At Eglin AFB field number 4, Prime BEEF teams deploy and conduct realistic force beddown and RRR training (162). In 1982, USAFE established the 7002 CE flight at Ramstein AB. All AFCE personnel assigned to USAFE must participate in the hands on construction of hard back tents, water treatment, field messing, barrier operations, and continuous generator operations (103). In addition, USAFE has an annual "RRR Olympics" in which teams from throughout the command compete to determine "The Best in USAFE" (145; 3). PACAF conducts similar training and annually conducts a large field training exercise in Korea (92).

The problem with these exercises is that only a relatively small percentage of AFCE personnel typically get to participate. Although Prime BEEF units at all USAF bases must participate in annual field exercises at their bases, these cannot match the realism nor the experiences of real world contingencies or major joint exercises. Lieutenant General Gast explains that operators and engineers are readiness partners and challenges AFCE to learn from its peacetime experiences:

> The challenge to the Engineering and Services communities is to sift carefully through the after action reports and the experiences of our people, to determine our true abilities to respond. Intense review and profiting from past challenges will enable us to to more effectively provide the operating support necessary to sustain any future effort.[89]

Bare Basing and Support Kits.

One of the most significant developments of the Vietnam conflict was the Bare Basing concept (159). Tactical operations could dictate that TAC units deploy almost anywhere; however, TAC could not assume that airbases are available wherever and whenever they need them (164). Bare Basing provided an economical means of establishing the required bases. This concept consisted of establishing Bare Bases, consisting of an airfield and a water source, at dispersed locations. Prepackaged support kits, containing the necessary supporting facilities and equipment, could then be deployed and set up by AFCE to make the Bare Base operational. However, there was only one US Army troop

construction unit, the 47th Engineer Combat Battalion (Airborne), specifically designed to rapidly construct Bare Bases in support of TAC (198).

Similar to the Bare Basing concept was the establishment of numerous Colocated Operating Bases (COBs) throughout Europe. Although these bases where considerably more than "Bare", only minimally essential facilities are continuously operated. As a result, the COBs require only one tenth the O&M budget of comparable Main Operating Bases (MOBs) (155).

There were two Bare Base support kits developed. These kits are designated as War Reserve Materiel (WRM) and were authorized because equipment supporting programmed peacetime operations was inadequate to support wartime activities identified in USAF War and Mobilization Plans (WMP) (221:3). Both kits, due to limited availability of excess kits, are also used for peacetime training. These AFCE base support packages are designated as Harvest Bare and Harvest Eagle.

Harvest Bare kits are designed to support up to 4500 personnel, aircraft, and other base maintenance and support functions (168). It includes mobile hard and soft wall facilities, and sufficient associated spare parts and housekeeping supplies for sixty days of independent operations. These spares and supplies are maintained in War Readiness Spares kits (WRSKs). The hardwall facilities are reusable, lightweight, and modular and consist of expandable personnel and container shelters, and modular general purpose warehouses and hangers (221:4). There are two Harvest Bare kits

in the USAF inventory, maintained in air transportable configuration, by the 4449th MOBSS at Holloman AFB, New Mexico (221:4).

Although Harvest Bare kits are ideal for AFCE support of a large deployed force there are two major problems associated with these kits. The first problem concerns the limited availability of the kits. During peacetime, only a limited number of kits are needed; however, if a major contingency occurs numerous kits would be required to support USAF operations. The second problem is related to the first in that only limited numbers of personnel can receive familiarization or training with the kits. Harvest Bare assets are unique and must be set up and maintained by trained personnel (70). Equipment spares are limited or unique, and the diesel and steam generators require continuous monitoring and maintenance (70).

Harvest Eagle sets are similar to the Gray Eagle kits used in Vietnam and are pelletized, air transportable, packages of softwall facilities, designed to billet, feed, and support up to 1100 persons. The sets again include sixty days of spares and supplies. They are designed to support any weapons system deployment but do not contain aircraft support equipment or facilities (221:4). The biggest problems with these sets is their limited availability and their age. The total number of sets in the USAF inventory is less

than half of those authorized in the WMP, and many of the sets have been maintained in WRM for years and are in a deteriorated state.

In addition to Harvest Bare and Harvest Eagle, deploying Prime BEEF teams are authorized housekeeping sets. These are custom tailored, base support oriented, sets of housekeeping, RRR, refueling, and communications equipment. These sets are not prepackaged but pallets are rapidly built up upon notification of deployment. Because the kits are custom tailored and vary in size and weight, airlift planning is difficult. The number and size of pallets is limited to available excess airlift capacity.(221:4)

Contingency Research and Development

In the past, AFCE had typically relied on civilian development of technology to meet its needs. After the Korean conflict, there was such an excessive amount of unused PSP accumulated that research and development of all expedient airfield surfaces was halted until surplus PSP could be exhausted. The US Army developed most of the expedient surfaces used in Vietnam; however, the USAF realized that an organic AFCE research and development effort was needed.

In 1968, Major General Guy H. Goddard, HQ USAF, Director of Civil Engineering, established the Air Force Civil Engineering Center (AFCEC) at Wright-Patterson AFB (192). This center was a field extension of the Air Staff

with the responsibility for such mission support functions as fire/crash rescue, airfield pavements evaluation, runway roughness measuring, aircraft arresting systems, airfield ice control, and development of modular facilities. In addition, the center was responsible for the structuring and tasking, and the development of training criteria for RED HORSE and Prime BEEF (54). The AFCEC was assigned to AFSC in 1972 and later came under the Air Force Engineering and Services Agency (AFESA) in 1977. The AFESA was responsible for the AFCEC (later renamed the Air Force Engineering and Services Center (AFESC)), the Air Force Regional Civil Engineers (AFRCEs), the Air Force Commissaries (AFCOMS), the Air force Mortuary Service, and the Air Force Services office (132).

As mentioned earlier, the center is responsible for structuring and posturing of RED HORSE and Prime BEEF. In the post Vietnam years, RED HORSE has been organized into deployable echelons, and Prime BEEF has experienced two major reorganizations. The next several paragraphs describe these evolutionary changes.

RED HORSE Organization. The initial concept of RED HORSE is still essentially the same. RED HORSE squadrons are unique civil engineering units capable of operating independently in the field (62:10). All RED HORSE squadrons have the following capabilities:

Airfield lighting installation
Communications
Concrete mobile operations
Explosive demolition operations
Expedient aircraft arresting barrier installation
Materials testing
Quarry operations
Rapid runway repair
Revetment erection
Water well drilling
Disaster preparedness mobility team
Bare base installation

These squadrons are highly mobile and world wide deployable. Squadrons assigned to overseas theaters during peacetime must maintain the same mobility requirements as other units, but are considered as foreward deployed to their expected theater of operations.

The types of personnel assigned to RED HORSE squadrons are essentially unchanged from the initial manning concept used in Vietnam. Squadrons are still based on a force of 388 enlisted and 12 officers, and assigned by Air Force specialty. Each squadron also has the authority to augment this military workforce by hiring civilians, with the approval of each squadron's respective MAJCOM (62:10-11). Due to the possible hostile conditions under which RED HORSE operates, all personnel assigned must be medically qualified for world wide deployment and be qualified to be armed and trained for their unique RED HORSE duties (62:11).

RED HORSE squadrons are organized into three echelons for deployment, designated RH-1, RH-2, and RH-3. Each of these echelons has a unique Unit Type Code (UTC) as

described in US Air Force War and Mobilization Plan, volume 3 (WMP 3) with the Tactical Air Command being the responsible command for these UTC's (62:13).

The RH-1 echelon is the smallest, in terms of men and material, of the three echelons, and is the first team to arrive at the deployed location. This unit has the Chief of Engineering as its team chief and is responsible for the initial site and airfield surveys, preparation of site plans for follow-on force beddown, and makes recommendations for appropriate support kits which might be required, such as Harvest Eagle and Harvest Bare. This unit deploys usually on C-141 or C-130 aircraft and is capable of independent operations for up to 5 days (62:13).

The RH-2 echelon is the next largest team and will also deploy on C-130 and C-141 aircraft, although some outsized pieces of equipment may have to be transported on C-5 aircraft. This unit is responsible for land clearing, site stabilization, erection of support kits, drilling of water wells, and installation of expedient aircraft arresting barriers. They are also capable of rapid runway and limited bomb damage repair. If this unit's consumable supplies are resupplied, it may operate independently for up to 60 days.

The RH-3 echelon is the largest of the three echelons and usually deploys by surface movement, but may deploy on C-5 aircraft. It has all of the capability of the RH-2 echelon plus is capable of heavy repair operations. It has the additional capability of being able to maintain quarry

and mineral product plant operations. As long as consumables are resupplied, this echelon may operate independently of base support indefinitely (62:14).

Because of the self sustaining and independent nature of RED HORSE it may be employed in many ways. Each RED HORSE can operate in any of the following modes:

a. Entire squadron at one location
b. Core squadron with detachments
c. Combined RH-1 and RH-2 deployment
d. Specialized or tailored detachment deployment

The core squadron consists of less than a full squadron deployment but must involve more than 75 personnel (62:14). The employment mode is dependent on the theater of operation responsibility, and the contingency and mission involved.

Prime BEEF Reorganizations. During the Vietnam conflict, Prime BEEF had been organized to provide home base recovery and deployed force beddown (60). The record of Prime BEEF during the conflict was outstanding; however, it became apparent that the original structuring of Prime BEEF was not conducive to or allowed training for such AFCE wartime roles as Bomb Damage Repair (BDR) or Rapid Runway Repair (RRR). Essentially this dictated a reorganization of Prime BEEF and by 1979 the first reorganization had been developed and consisted of the following building block, contingency force (CF) teams (61):

CF-1: 21 man team consisting of pavement maintenance specialists and equipment operators, designed for RRR and capable of deploying independently; however, if must be paired with a CF-2 team if horizontal and vertical BDR is required.

CF-2: 70 man team made of all AFCE specialties, designed for base recovery operations.

CF-3: 35 man team designed for emergency construction management and work control functions.

CF-4: Consists of a command and staff element, designed to augment a theater command engineering staff.

CF-5: 12 man team of fire/crash rescue specialists.

CF-6: Fire fighting command and control element.

AFCE was still faced with not being able to fully allocate its personnel to wartime roles, and contingency plans tasking did not coincide with the team structuring. There were shortages at some bases and overages of like specialists at other bases. The center developed a new organization in 1983 to alleviate these problems and this new organization consists of the following Prime BEEF (PB) teams (32):

PB-1: 15 man engineering staff, designed to operate at COBs or augment existing staffs at MOBs, includes BCEs and First Sergeants.

PB-2: 45 man team of various AFCE specialties, designed for base support and recovery.

PB-3: 20 man team of various AFCE specialties, designed for limited support.

PB-4: 12 man pavement maintenance and equipment team, designed for RRR.

PB-6,7,8: PB-6 and 7 parallel CF-5 and 6, with PB-8 being a three man team to provide flexibility.

PB-9 through 26: 3 man teams of like specialties to provide flexibility and augment PB-2 and 3 teams.

There has been mixed acceptance by the AFCE community over the latest reorganization of Prime BEEF. Brigadier General Ahearn, HQ USAFE, Deputy Chief of Staff for Engineering and Services, feels that the posturing may change again before the reorganization is fully implemented (3). Brigadier General Ellis, HQ USAF, Deputy Director for Engineering and Services, although he admits to initiating the new organization, believes that there are significant problems with the new posturing. He feels that the logistics associated with getting the numerous three-man teams from their home bases to their assigned overseas theaters have not been adequately considered and may in fact be insurmountable (76). Major General Wright, HQ USAF, Director of Engineering and Services, supports the new posturing; however, he does acknowledge that there may be problems with it (245). All three of these top AFCEs believe that the new organization must be tested before conclusions can be drawn. Regardless of how the Prime BEEF teams are eventually postured, the program must be preserved, for only through Prime BEEF can the Air Force have a skilled engineering force ready to deploy anywhere in the world, or to man RED HORSE, in support of Air Force operations (159; 91).

RRR Development. The US maintained air supremacy during the Vietnam conflict and airfield damage was limited to damage from mortar and rocket attacks. The small craters and spalls were quickly repaired using epoxy resins or high early strength concrete with little impact on flying

operations. However, in the post Vietnam era, emphasis has been shifted to the North Atlantic Treaty Organization (NATO) theater where US air supremacy is not assured and attacks on NATO airfields would be far more severe than in Vietnam. The extensive aircraft sheltering programs have made parked aircraft difficult to attack and made the airfields more desirable targets (22). In current weapons systems, the airfields remain the weak link of the weapons systems (22).

Since 1974, successful RRR has been based on being able to repair three 750 pound bomb craters in four hours. AM-2 matting had been used as an expedient airfield surface in Vietnam with good results and the first RRR was conducted using AM-2. The process consisted of pushing material ejected from the crater back into the crater, removing large chunks which could not be properly compacted, filling with 12 to 24 inches of select fill, leveling, then placing the assembled AM-2 mat over the crater and anchoring the trailing and leading edges. This technique successfully met the three crater/four hour criteria and numerous AM-2 RRR kits were prepositioned at overseas locations. Although alternate RRR techniques were tested at the center, AM-2 remained the best alternative.(29; 31)

It became apparent that the three crater/four hour criteria was not sufficient to "win the war" (31). In 1978, the center initiated research and development to enable launch and recovery of aircraft in one hour. This effort

initiated research into damage assessment, mobile arresting barriers, alternate launch surfaces, mobile launch platforms, vertical and short take off and landing aircraft, as well as RRR techniques. Although crater filling, compacting, and leveling must still be conducted, three promising surfacing techniques were developed.

In USAFE, the "two meter square" technique was developed. Here the crater surface is enlarged into square shapes by sawcutting the airfield to accommodate precast concrete slabs two meters by two meters. Although this technique is equipment intensive it does decrease the repair time and Brigadier General Ahearn has high hopes for it (3). The major drawback of this technique is that the sawcuts must be made to tight tolerances, requiring highly skilled specialists, and increasing the repair time significantly if not done properly.(3)

In PACAF, where equipment availability is limited, a technique using a resin impregnated fiberglass mat was developed as a successful time saving alternative. Here the mat is placed over compacted, crushed aggregate and Colonel Glaze, HQ PACAF, Deputy Chief of Staff for Engineering and Services, feels this technique is the best for PACAF bases (92). The biggest problem with this technique is that the mat is subject to tearing at places where aircraft must turn or brake (92).

The third technique is also the most promising. Again craters must be filled but the surface is now a polymer

concrete. This technique is also equipment intensive and relatively expensive due to the short shelf lives of the polymer components; however, tests at the center have been extremely successful.(245)

The AM-2 technique continued to be the primary RRR technique through 1983 but testing was continued on the alternate RRR techniques. In the spring of 1985 the "two meter square", fiberglass mat, and polymer concrete techniques were tested under wartime operational conditions at the Salty Demo exercise. Although results of the exercise have not yet been released, General Wright has stated that none of the three techniques was entirely successful and the RRR problem still exists (246).

AFCE Contingency Planning

AFCE support requirements are included in the support planning of the Joint Operation and Planning System (JOPS). Supported commanders task one or more of their service components to develop a Civil Engineering Support Plan (CESP) for a specific area. Each of the other service components, whose forces will be using facilities in the affected area, must provide their civil engineering support requirements to the service component tasked to develop the area CESP. The supported command staffs consolidates the area CESPs into a single CESP for inclusion in the Operations Plan (OPLAN). (220)

A specialized JOPS Automated Data Processing (ADP) program called the Civil Engineering Support Plan Generator Plan Generator (CESPG), assists the planners in the development of CESPs. The CESPG helps the planners to determine the amount of manpower, equipment, and materials needed to construct and upgrade facilities that support the forces in the OPLAN. The program also forecasts attrition rates and expected war damage and repairs. The CESPG interacts with a number of programs in the Worldwide Military Command and Control System (WWMCCS) to prepare CESPs (220). The CESPG software is made up of five major modules: 1) Maintenance module, which consist of programs to update, verify, and print files from the data base; 2) Analysis module, which extracts troop movement data to analyze the effect on base complexes; 3) Requirements Generator module, which determines facilities required and tasks construction units; 4) Scheduler module, computes manpower requirements and schedules engineering units; and 5) Tabs module, which generates various reports that may be required.(220)

The biggest problem with this AFCE planning system is that actual site information may vary from that stored in the data base. Commanders and those controlling the funding may look at the CESPs as gospel and not realize the need for any flexibility that may be required due to inaccurate or

unforeseen site conditions. This could lead to the same problem experienced in Vietnam of AFCE support always lagging force build-up.

Summary

In the post Vietnam era, many advances have been made to improve AFCE's ability to support USAF forces. However, a complete summarization of current problems was not possible due to the classified documents associated with post Vietnam warfighting capabilities. Immediately following the Vietnam conflict, AFCE was faced with minimal budgets, and the possibility of losing the troop construction capabilities developed in the 1960s. Although cutbacks were made, Prime BEEF and RED HORSE are now firmly entrenched in AFCE and provide a credible AFCE warfighting capability. AFCE now has an R&D capability in the AFESC to develop solutions to AFCE problems. Support planning is far superior to previous methods. Although AFCE is more capable today, there are still many problem areas such as RRR, and Prime BEEF posturing.

VIII. Summary and Recommendations

Introduction

This research has presented a history of AFCE wartime and contingency problem areas from 1941 to the present. The research methodology was based on the writing of several historical researchers. The findings are presented in five chapters and represent a consolidation of hundreds of sources including end-of-tour reports, after action reports, research studies, personal interviews with past and present AFCE contingency experts, as well as numerous other sources.

The topic scope was narrowed and research questions were developed to provide a focus for this research. The remainder of this chapter presents a summary of the research findings along the guidelines of these research questions:

1. What were the major wartime and contingency problems that were experienced by AFCE from 1941 to the present?

2. What were the solutions to these problems and how effective were these solutions in terms of mission accomplishment within resource constraints?

3. Have there been any recurring problems and, if so, why did they recur?

4. What has been done and what is being done to prevent or reduce the impact of these recurring problems?

Finding the complete answers to the above questions was difficult and in some cases impossible; however, the major problems that have recurred throughout AFCE's history have

been identified. Although the circumstances have varied, the most critical problem areas for AFCE have been: 1) USAF organic troop construction capability; 2) contingency base civil engineering operations and maintenance; 3) contingency engineering technical deficiencies; 4) prefabricated facilities standardization and support kits; 5) AFCE hierarchy and status in the USAF organization; 6) AFCE logistics support; 7) construction equipment; and 8) the proficiency and wartime readiness of its personnel. The history of problems with each of these areas is discussed in summary form.

Summary of Significant Findings

USAF Troop Construction Capabilities. During WWII, the initial Army Air Force (AAF) and U.S. Army organizations allowed for specially skilled and equipped engineers, trained in airfield construction, to support AAF contingency requirements. However, the Army maintained control over these Aviation Engineer units and more often than not the units were tasked for priority Army projects, with AAF priorities taking a back seat. It was not until the establishment of the 12th Aviation Engineer Command in North Africa, and the 9th AAF Engineer Command in Europe that the AAF gained control of its troop construction units. This gave the AAF a very credible troop construction capability in WWII; however, the Aviation Engineer units were disbanded in the massive demobilization of armed forces following WWII.

The National Security Act of 1947 established the U.S. Air Force and stated that duplication of forces should be minimized. Although the Air Force was responsible to provide the forces necessary to project air power, if the Army or the Navy had an existing support capability, the Air Force could not duplicate it and had to rely on the Army or the Navy for support. The act did state that the Air Force had responsibility for maintenance and repair of its installations; however, no provisions for wartime construction responsibilities were made, and it was assumed that this would be an Army responsibility.

Going into the next major contingency, the Korean War, SCARWAF units were available. These units were manned and equipped by the Air Force but trained and controlled by the Army. The Army controlled these units up to the point where the Air Force needed them in a contingency. Prior to the Korean War, these units were grossly undermanned, ill-trained, and poorly equipped and would prove completely ineffective in the Korean War. In 1951, the Aviation Engineer Forces (AEF), were established under CONAC, which provided the Air Force with absolute control over its engineer units. This troop construction capability was maintained through the Korean War; however, in the demobilization after the conflict, all AEF and SCARWAF units were disbanded. This left the Air Force with no contingency troop construction capability.

For years this situation remained. During the 1958 Lebanon and the 1961 Berlin incidents, Air Force requirements were accomplished either with in-house BCE forces or with USAFE mobile teams. However, these ad hoc forces were extremely limited in their capability, and were used primarily for light vertical construction.

As U.S. involvement in Vietnam began to escalate, BCE forces were initially augmented with TDY personnel from PACAF and the CONUS, again in an ad hoc fashion. These mobility teams were not formalized until the establishment of Prime BEEF. Although the Prime BEEF teams were extremely successful, their capabilities were restricted by their dependence on local BCEs and bases for support, the small size of the teams, and the temporary nature of their employment on a TDY basis in Vietnam. This led to the development of RED HORSE, which gave the Air Force a long awaited self supporting, organic heavy repair capability, with a collateral heavy construction capability.

Prime BEEF and RED HORSE supplemented and complemented one another superbly and were extremely successful in Vietnam. However, in the years following the conflict, the Army again tried to regain control of all troop construction and the Air Force was faced with losing its RED HORSE units. It was not until 1978 that the JCS decided the issue in favor of the Air Force retaining its Prime BEEF and RED HORSE capabilities. Although the organizational structure

and missions of these units are still evolving, the Air Force maintains control of its extremely capable troop construction units.

Contingency O&M. This next major problem area concerns BCE operation and maintenance including bomb damage repair, in a contingency environment. During WWII, BCE O&M varied with the theater of operations. Some of the engineers were in Engineer Aviation Brigades, the Air Service Command, worked for the Army Services of Supply, in veritable hodge-podge. In the late 1940s, Air Installations Officers (AIOs) were established, which formalized base engineering forces. Early AIO organizations were given low priority, manned with personnel who had typically failed in other specialties, and equipped with old equipment and tools long since worn out in WWII. It was fortunate that the USAF maintained air superiority and that extensive bomb damage repairs were never required, except where the USAF had bombed an area, driven the enemy out, and then started using facilities.

Again during the Vietnam conflict, air superiority was maintained and only limited bomb damage repair was required. The Prime BEEF and RED HORSE units were ideal for augmenting the BCE forces, providing emergency construction, and extremely capable bomb damage repair.

In future conflicts, U.S. air superiority is not assured. With the worldwide extensive aircraft sheltering programs, airfield surfaces have become primary targets and

remain the weak link in the weapon systems. Rapid Runway Repair and Air Base Survivability are real concerns and will remain primary missions for Prime BEEF and RED HORSE in future contingencies.

Technical Problems. Technical engineering concerns have also plagued AFCE. Airfield siting, drainage considerations, and soil conditions have not been adequately considered in airfield construction. In WWII, various expedient airfield surfaces were used including wood mats, bituminous cloth surfaces, and PSP; however, the only surface suitable for the jets in Korea was PSP. If the airfields were not located or constructed properly, subbases would wash out or be blown out by jet blasts and this would cause frequent airfield failures.

The initial criteria for facility construction in Korea was based on a six-month life expectancy. When the six months were passed, AIOs were faced with the maintenance headache of keeping these expedient facilities open. Ill-prepared asphalt and unreinforced concrete airfields crumbled under sustained jet aircraft operations.

Again in Vietnam, airfields were underdesigned and improperly sited. BCE maintenance problems were magnified and construction costs were inflated. Junior officers were not familiar with heavy construction techniques, or soil compaction and facility heuristic engineering practices predominated. AFCE junior officers need to be familiar with these techniques before entering contingencies.

There was such an excess of PSP, following the Korean War, that Air Force expedient airfield research and development was halted until this surplus was used. The U.S. Army developed and used several expedient surfaces in Vietnam and AM-2 matting proved to be the most successful expedient airfield surface. Nearly twenty years later, AM-2 remains the primary expedient airfield surface.

Prefabricated Facilities and Support Kits. During WWII and Korea, prefabricated facilities consisted primarily of quanset huts and it was not until the Vietnam conflict that different prefabricated facilities were used. In Vietnam, inflatable shelters, trailers, and a few modular facilities, were used but, as in previous contingencies, wood frame structures and tents predominated. There were no prepackaged kits available with facilities, rations, or equipment that could be used for the rapid deployment of forces.

WWII equipment was typically new, off-the-shelf equipment, which performed admirably during the war; however, the same equipment (now with several thousand operating hours) was used in Korea. As equipment failed it was replaced with dissimilar items and this presented logistics nightmares of trying to maintain the myriad of required spares.

By the time the Vietnam conflict was escalated, existing equipment had to be completely replaced. This provided new equipment in every area save generators. There were over 50 makes and models of generators in Vietnam, each

requiring its own spare parts and few technicians could repair more than a few of the types. Power production was never able to match the requirement throughout the Vietnam conflict.

In the Post Vietnam era, base support kits have been developed and are designated Harvest Bare and Harvest Eagle. These kits are prepackaged, and include housekeeping supplies, facilities, and equipment for force beddown excluding aircraft support. The problem with these kits is that only half of the authorizations have been filled, and only a few personnel train with them because of their limited availability.

AFCE Organizational Hierarchy. During WWII, AAF engineers were subject to the whims of the Army until the establishment of the Aviation Engineer commands. Again in the Korean War, engineer units were relatively ineffective until a separate Deputy Chief of Staff (DCS) was established for Air Force engineering in the 5th AF.

In the years following the Korean War, the Directorate of Civil Engineering bounced around under the various DCSs at the Air Staff. Engineering has been under operations, personnel, logistics and programs. This rather unstable condition has caused problems for AFCE. Civil Engineering considerations for support, weapons systems development, and manning having not always carried the support of the various Air Staff DCSs. This has led to logistics support and

manning problems for AFCE. However, the Directorate of Air Force Engineering and Services now appears to be properly located and well supported.

Logistics Support. During WWII, the Army was responsible for engineering supplies, and regardless of who generated the requirement, Army units were supplied before AAF engineers. Establishment of the Engineer Commands, helped this problem, but, engineer requirements were never adequately considered through the Korean War. However, engineers were not unique in their supply problems in Korea and Vietnam. Even if supplies were received at in country ports, transportation networks within the countries were grossly inadequate and supplies accumulated on the coasts.

Personnel. Army personnel assigned to engineer units in WWII were assigned without regard to prior job experience or ability. In many cases, once personnel were given engineering experience, if they were physically capable they were reassigned to combat units. SCARWAF units in Korea were poorly trained and the situation improved only slightly with the establishment of AEFs.

AFCE personnel in Vietnam were not used to working alone and had usually been subordinate to civilian tradesmen in previous assignments. The one year tour in Vietnam was sufficient to give personnel valuable experience, but, BCEs were constantly faced with an influx of inexperienced personnel and losing their experienced people. This problem

still exists today with military craftsmen typically being subordinate to civilian tradesmen and not receiving sufficient training to accomplish their wartime skills.

Recommendations

The biggest problem which the authors faced in conducting this research was the lack of detailed unit histories. Although these unit histories are required at base, Major Command, and Air Staff levels, they are accomplished so as to be of little use. Problem areas are either glossed over or omitted with only period accomplishments being addressed. Unit histories at all levels should expound on the problems encountered, and a "lessons learned" section should be mandatory.

The authors were surprised to find the general lack of AFCE historical knowledge among their peers and also among some of their superiors. The authors recommend that a course on AFCE be offered through the Air Force Institute of Technology for all AFCE officers, and an historical block be mandatory in the Base Civil Engineer introductory course currently offered through the School of Civil Engineering.

The authors realize the limitations of this research and recommend that the newly established historian for Engineering and Services, distribute this report to AFCE experts for their additional comments. It was impossible to interview all of the AFCE contingency experts and this may have resulted in gaps in the research, especially in the

time periods between the major conflicts where only limited documentation was available or was of a classified nature. Additional expert opinions are required to discover any gaps that may exist and to aid in any future related research.

This research is only a part of the entire Engineering and Services picture and cannot stand alone. Many areas could not be addressed due to the tremendous number of sources, the limited time available, and the inaccessibility of many of the sources. Some recommended areas of further study include, but are by no means limited to:

Services
Construction Initiatives
Quality of Life Initiatives
Fire Protection
Housing
Organizational Structure and Changes

Engineering and Services' peacetime and wartime experiences must be examined together to maximize the value of the historical lessons. When the remaining topical areas are covered and their histories written, they will provide an essential tool in future Engineering and Services development.

The final recommendation is to emphasize the importance of continuing to update this research. The classified nature of the after action reports in the post Vietnam era did not allow for the experiences and problems of the era to be fully included in this research. It would be a great loss to allow this research to stagnate on a shelf or in some archives.

APPENDIX A: Army-Air Force Agreement Excerpt (1949)

SECTION V
AGREEMENTS ON SERVICE, SUPPLY
AND PROCUREMENT (LOGISTICS) FUNCTIONS

GENERAL

Each department shall make use of the means and facilities of the other departments in all cases where economy consistent with operational efficiency will result. Except as otherwise mutually agreed upon, cross-servicing and cross-procurement as now in effect will continue until modified by the Secretary of Defense.

SERVICE ACTIVITIES

1. Real Estate and Construction

a. The Army and the Air Force will individually determine their separate requirements for real estate and construction and defend those requirements in their individual budget estimates.

b. The Army will acquire and dispose of real estate for itself and act as agent in the acquisition and disposal of real estate for the Air Force.

c. The Army will continue to act as custodian of all legal records pertaining to real estate for the Army and the Air Force, as now in effect, unless other arrangements are directed by the Secretary of Defense.

d. The Army is designated as the contract construction agent for the Air Force. The Air Force will provide funds for such construction, will collaborate in the preparation of specifications, including layout and architectural design, and will review and approve contracts prior to awards. Design of specialized technical facilities for Air Force use will be the responsibility of the Air Force.

2. Repairs and Utilities

a. The Army and the Air Force will individually determine their separate requirements, qualitative and quantitative, for all personnel, material, and services, and defend these requirements within their separate budget estimates. Each department will administer, direct, and supervise repairs and utilities activities at its own installations.

b. Repairs and utilities technical standards and general policies will be developed by joint agreement wherever possible and promulgated by each department, otherwise by direction of the Secretary of Defense.

c. Contracts for the purchase of utilities services (gas, water, electricity, etc.) will be negotiated and executed by the respective departments, governed by established joint policies. Where economy and efficiency, consistent with operational requirements, would result, one department will include provision for utility contract services for all other departments in a specified locality.

10. Maintenance

a. Organization maintenance and field maintenance at the below installation level will be performed by each Department.

b. Base maintenance (depot maintenance in Army Air Forces) of all items (peculiar and common) will normally be performed by the Department having procurement responsibility except that base maintenance responsibility in specific areas and for specific items may be otherwise assigned by mutual agreement or by direction of the Secretary of Defense in the interest of economy and efficiency.

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He then majored in Mechanical Engineering at the University of Dayton for two years before entering the USAF. He enlisted in the Air Force in 1976 and worked as an Avionics Communications Specialist for three and a half years at Kirtland AFB, New Mexico. By 1979, he had been selected for the Airman Educatior and Commissioning Program; and he graduated from the University of New Mexico with a BS in Civil Engineering in December 1981, and became an Engineer in Training. Upon completing Officer's Training School, he was assigned to the 1st CES at Langley AFB, Virginia. While at Langley, he worked as a design engineer, a contract programmer, and as the Chief of the Environmental and Contract Planning section.

VITA

Captain L. Dean Waggoner

He

enrolled at the University of Alabama. Captain Waggoner graduated from the University of Alabama with a Bachelors of Science Degree in Civil Engineering and was awarded a commission in the USAF by the ROTC in 1979. He entered active duty in June of 1979 when he was assigned to the 2750th Civil Engineering Squadron at Wright-Patterson Air Force Base. While at Wright-Patterson, Captain Waggoner developed designs and specifications for base projects, served as a contract manager and temporarily acted as the Squadron Section Commander. In 1981, Captain Waggoner was reassigned to the 10th Combat Support Group Civil Engineerig Squadron at RAF Alconbury in the United Kingdom. Captain Waggoner served as the Chief of Contract and Environmental Planning, the Chief of Contract Management and later as the Chief of Engineering. In 1984, Captain Waggoner was selected to attend the Air Force Institute of Technology's School of Systems and Logistics, where he was enrolled in the Graduate Engineering Management Degree Program.

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This research presents a history of Air Force Civil Engineering contingency and wartime problems from 1941 to the present. Air Force Civil Engineering's lack of a consolidated historical document precluded the use of past experiences to plan for the future. Historical research techniques were used to conslidate the historical information from the Simpson Historical Research Center, the Office of the Air Force Historian, the Air Force Institute of Technology libraries, and interviews with several past Air Force Civil Engineering leaders and contingency experts. The findings from these numerous sources are presented in five chapters: 1) experiences of aviation engineers during WWII; 2) experiences prior to and during the Korean conflict; 3) experiences of the post-Korea/pre-Vietnam era; 4) problems and significant advancements of the Vietnam era; and 5) Air Force Civil Engineering evolutions in the post-Vietnam era including some current initiatives. This research indicated that Air Force Civil Engineering problems of the past occurred and continue to occur because of technical deficiencies, economic limitations, political restrictions, and because Air Force Civil Engineering has failed to properly learn and use the lessons of the past to prepare for the future.

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